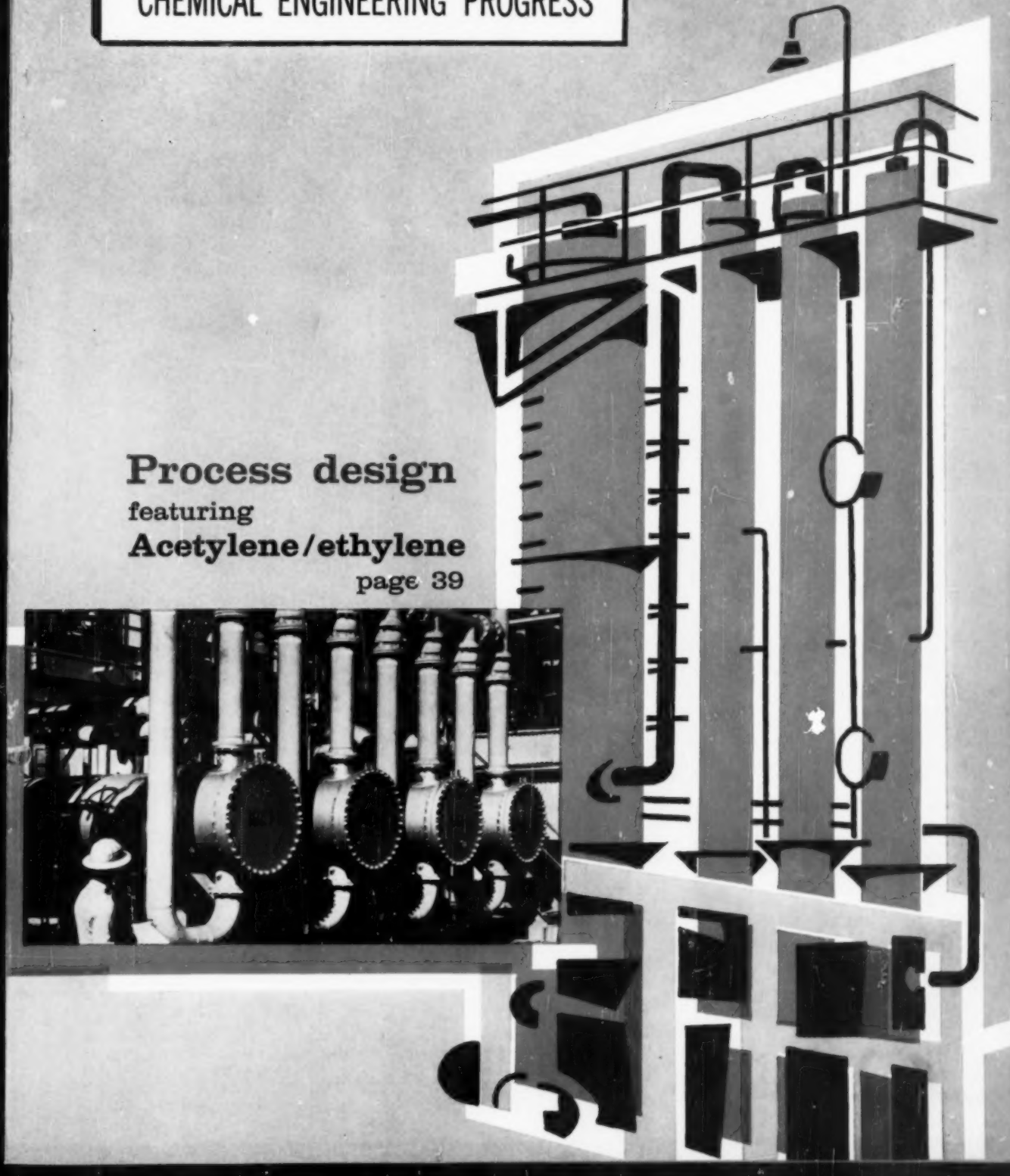
CEP

CHEMICAL ENGINEERING PROGRESS

JANUARY 1960



Process design

featuring

Acetylene/ethylene

page 39

CEP

CHEMICAL ENGINEERING PROGRESS

January 1960 Volume 56, No. 1

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Cover by Paul Arit.

.... in this issue

(Continued on page 5)

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Problem:

Acid entrainment from tail-gas stacks in a sulfuric acid plant was the cause of a bad air pollution problem, which included considerable paint damage, especially to automobiles in adjacent areas.

Solution:

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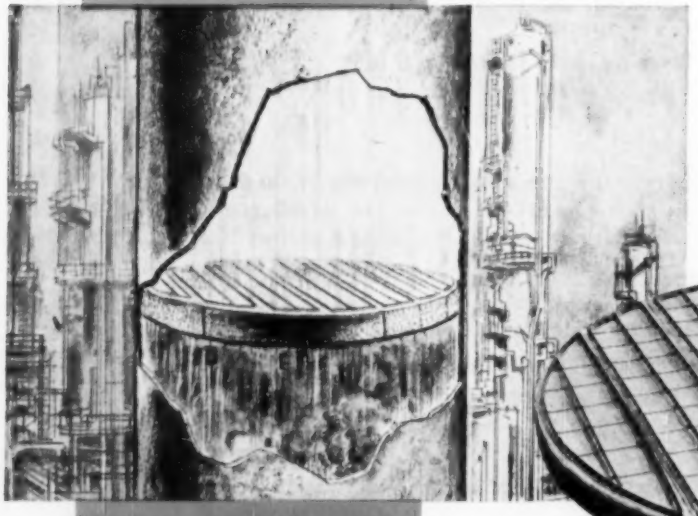

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For more information, turn to Data Service card, circle No. 81

CEP .... in this issue

(Continued from page 3)

departmental features

marginal notes

Practical heat exchanger and petroleum refinery manuals aid engineers

HEAT EXCHANGERS: Process Heat Exchanger Division, Patterson-Kelley Co., Inc., East Stroudsburg, Pa.

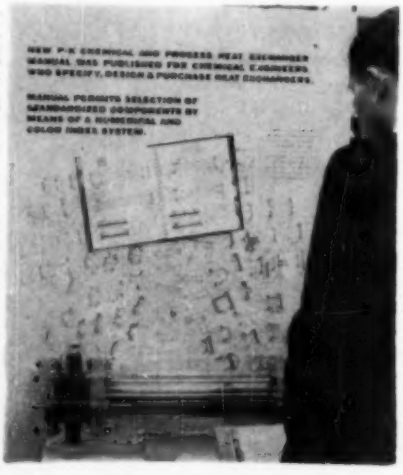
This book is a primer dealing with variables relating to the design and fabrication of heat exchangers. Clearly described, on 8½ by 11 inch pages, are heat exchanger components, design features, economic considerations, plant facilities, and much more desirable information.

The material is put together in a unique manner, profuse with illustrations, brief in written matter. Illustrations are varied; cross sections, outlines, assemblies, photographs, and caricatures. The first section, in only seven pages, describes the various designs used most often, namely: U-tube, fixed tubesheet, and four common types of floating-head designs. Mention is made of tubeside pass arrangements, shellside tube supports or baffles, and the three principal components: front heat, rear head, and shell sections. This section concludes with a single-page table exhibiting the special features of each type of design.

The second section contains less than one page of written matter, but more than 150 colored illustrations of various parts: front heads in red, shell sections in gray, and rear heads in blue. By use of a simple code system for identifying each unique feature, customer and vendor are assured of mutual understanding on the desired design at the times of inquiry and proposal.

In Section C, all of the principal parts are illustrated in half-sectional assembly drawings, and the names usually associated with these parts are contained in a table of nomenclature. Then follow several pages of gasket joint designs and tube to tubesheet joining methods. In sixteen line drawings, various tube-pass partition designs are shown. On the same page three types of tube pitch and six types of tubesheet designs are described. Various tubeside and shellside nozzle orientations are described on page 10 of this 14 page section which concludes with detailed descriptions of minor shell component designs such as vapor belts, supports, baffles, and expansion joints.

The fourth section, of necessity, contains a considerable amount of description since it treats of economic considerations and fundamental heat transfer. Illustrations of assembled, stacked, and partially assembled heat exchangers follow in the next section. Various photographs of the Patterson-Kelley shops and of exchangers in industrial plants compose the last eight pages of this section.



Patterson-Kelley featured its new manual at the recent Chem Show in New York.

In the final section, the compilers have presented a very comprehensive technical design check list. Although it takes some six pages of descriptive matter to indicate what information the vendor needs to know in order to present a satisfactory proposal, this space is well used. Copies of a comprehensive inquiry data sheet for heat exchangers are enclosed in an envelope inside the back cover of the book. In concluding this section; information on corrosion, fouling, and physical properties of fluids is presented.

In this book, the Patterson-Kelley Company presents material, not found elsewhere, which effectively bridges the gap between heat exchanger design and fabrication. The descriptive matter in both words and illustration is excellent. Practically every conceivable variation in construction is included.

The primary reason for publication of this book is given in the foreword—"To remove communications barriers in the selection of heat exchange equipment." In this, the compilers have succeeded very well. At the same time the reader, at once, perceives that the Patterson-Kelley Company possesses considerable knowledge in regard to heat exchanger fabrication. The vendor's sales force should find this to be a most successful tool for selling heat exchangers. The purchaser's Engineering Department will find this book to be informative, instructive, and useful in planning the designs of heat exchangers. The interesting caricatures and illustrations make it an easy book to read and a welcome substitute for one's own scribbles on a scratch pad. Congratulations to Patterson-Kelley for a job well done and for pioneering on a much needed addition to the understanding of heat exchanger design and fabrication.

Reviewed by C. H. Gilmour, Union Carbide Chemicals Company.

continued on page 8

Marginal notes

from page 6

PETROLEUM REFINERY MANUAL, Henry Martyn Noel, Reinhold Publishing Corporation, 430 Park Avenue, New York City, 182 p., $7.95.

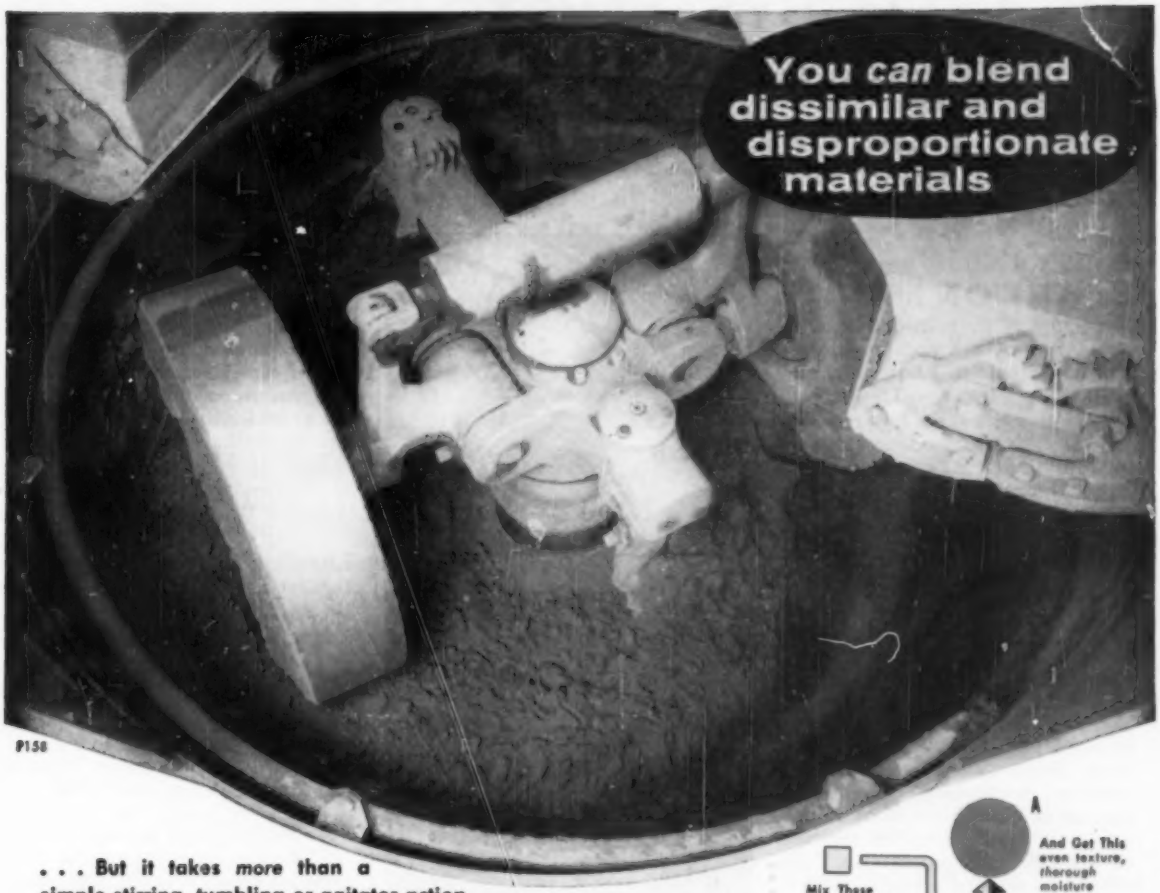
The approach taken by the author is to trace in great detail the progress of typical petroleum refinery construction projects from the time research has been completed to the initial operation of a new process unit. His development of each phase of the project is to list some of the possible events, with accompanying figures as to time element, manpower required, and costs that he considers typical for these items. The author systematically moves from point to point in a careful chronological sequence, noting factors that must be considered, problems that may arise. It is apparent that he has leaned heavily, if not exclusively, on the records of dozens of projects carried through by Esso Research and Engineering Company in behalf of the affiliates of Standard Oil Company (New Jersey). A relatively high proportion of the references are to construction projects in foreign countries.

The result is a compendium of examples which should be very effective in giving perspective in this field to one who is relatively unacquainted with it. Thus, it might prove to be a valuable training tool for new employees of a petroleum refinery engineering organization. On the other hand, it does not purport to be a source of design or project information for the initiated, except insofar as it might be a secondary check upon the reasonableness of a proposed project worked out in detail. Beyond this, for the most preliminary of studies, the typical figures given by the author should be usable in the screening of processes for a projected new refinery or operation. Overall, the book takes the form of a descriptive text in industrial engineering, rather than a source of technical information for direct use in working industrial problems.

The author is a veteran in refinery planning, construction and operation, having 31 years' experience with Standard Oil Company (N.J.), and its affiliates. He is now a consulting engineer with headquarters in New Canaan, Conn.

Reviewed by Dr. R. L. Dockendorff, Asst. Div. Head, Technical Div., Humble Oil & Refining Co., Baytown, Texas.

continued on page 10



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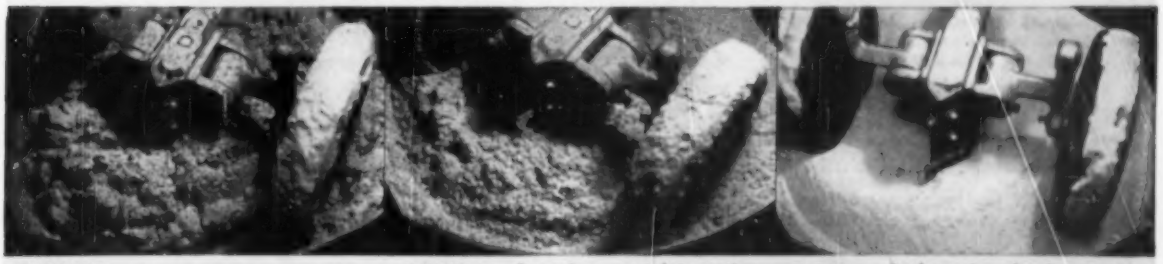

GOING. Mix is wetted, dispersion of coating media begins as lumps form.

GOING. Smearing, *spatulate* action breaks up lumps as mulling action disperses moisture.

GONE. Agglomerates almost gone as blending nears completion. Mix is homogeneous, thorough.

For more information, turn to Data Service card, circle No. 68

Marginal notes

from page 8

Recruiting Practices and Procedures, American Society for Engineering Education, (1959), 4p. $0.25.

Lists the responsibilities of the student, the school, and the employer in bringing college engineering students into employment in industry. This third revision of the 1949 publication contains greater detail about employment conditions most important to students. Copies of this report may be obtained from: W. Leighton Collins, Secretary, American Society for Engineering Education, University of Illinois, Urbana, Illinois.

Survey of Solubility Diagrams for Ternary and Quaternary Liquid Systems, D. M. Himmelblau, B. L. Brady, J. J. McKetta, Jr. Bureau of Engineering Research, The University of Texas, Austin 12, Texas. 42 p., $2.00.

Solubility data have become more abundant each year, and at the same time, buried in a mass of other concealing data. Often, the same data has to be recreated by time consuming laboratory experimentation, when a reference table would show where the desired information is. The authors, with this problem in mind, made a thorough survey of all the water and liquid systems published prior to 1958. The survey was based on a wide variety of periodicals, text books and industrial publications. Its purpose was to present comprehensive equilibrium solubility data in a manner that would afford a rapid means of checking previous work on the system in question.

The following groupings were presented in the survey: 1. Systems containing water and two organic compounds, with a cross reference between most common systems. 2. Non aqueous organic systems containing liquid propane and two non aqueous components. 4. Quaternary systems. 5. Systems containing water, one organic liquid and one metallic organic compound.

A nitrogen fertilizers production complex to be built for the Iranian government, by the French company ENSA. Under an agreement between ENSA and the Belgium firm, SABA, the latter will design the nitric acid and ammonium nitrate plant at Shiraz, Iran.

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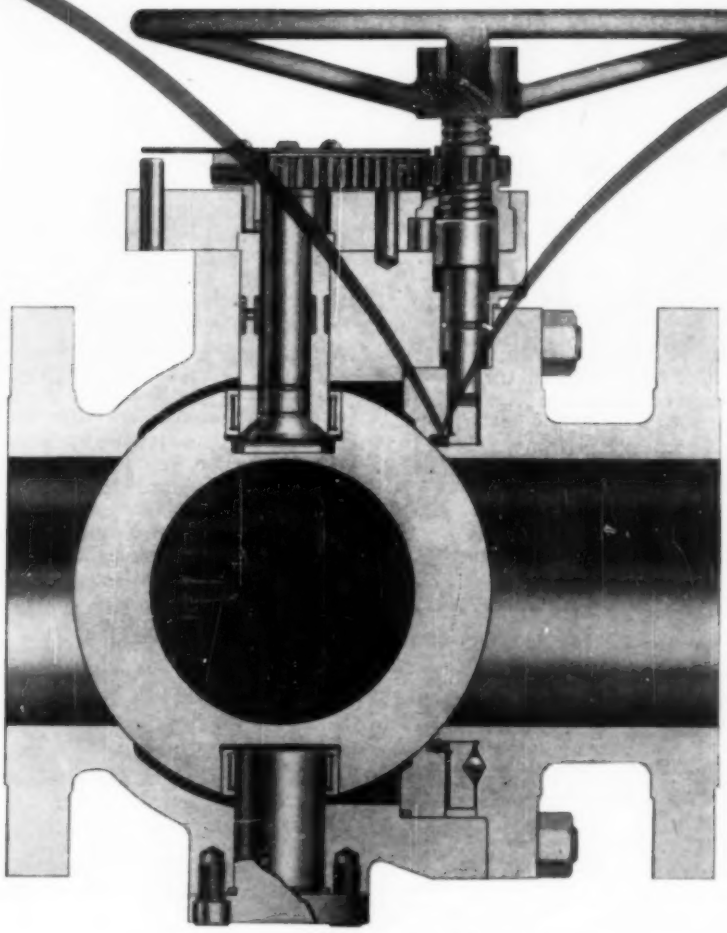

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For more information, turn to Data Service card, circle No. 99

about our authors

K. Kullberg (*Improved Heat Transfer Coefficients*) received his M. S. in chemical engineering from Case Institute of Technology in 1959, and is now employed in Dow Corning's training program. His work takes in process design, pilot plant operation and production. **H. B. Kendall,** a member of the chemical engineering faculty at Case, while primarily interested in heat transfer, is also engaged in research on chemical kinetics in flow systems.

KULLBERG

KENDALL

M. J. Barry, J. M. Fox, S. S. Grover, P. J. Leroux, and **D. F. Braconier** produced (*Acetylene - Ethylene from Naphtha*) as the result of collaboration on an international scale, between the Societé Belge de l'Azote and the Kellogg organizations. Barry, Fox and Grover were with Kellogg, while Leroux and Braconier are with SBA. Barry, now project manager at the New York firm, has been occupied with process development and design in the petroleum and petrochemical fields. He holds several patents. Fox is a member of the research planning group that does both long and short

BARRY

FOX

range planning in process research at Kellogg. Grover twice visited Belgium to work on the development of SBA's acetylene pilot plant. A chemistry graduate of East Punjab University in India, he has an MSE in chemical engineering from the University of Michigan. He is currently with Aerojet General's solid rocket plant in Sacramento, California. The European members of the team are in research and development at SBA, Braconier as director of the division, and Leroux head of the acetylene research and

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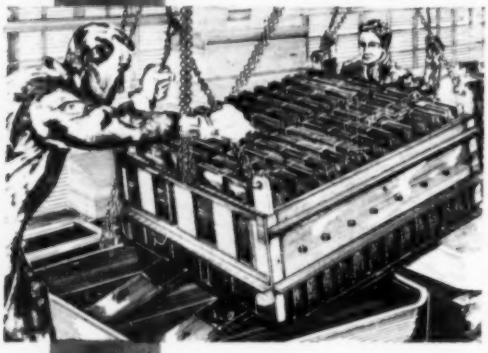
AN IMPORTANT MESSAGE FOR ELECTROLYTIC CELL OPERATORS



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These dividends have been developing during the past several years as a result of exchanges between GLC engineers and those of GLC customers.

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If you, as an electrolytic cell operator, are not as yet fully informed about the GLC program of technical exchanges with GLC Anode customers, and the results of this program which are now becoming evident, we will be happy to furnish such information to you.

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U. S.–USSR jockey for space

Temporary lead of Soviets to be expected; spectaculars mustn't be overemphasized, Kistiakowsky says.

"If we don't want our technological progress to slow down, more effort must be put into the basic scientific research from which our technology derives," said Dr. George B. Kistiakowsky, keynoting his position as Special Assistant to the President for Science and Technology.

For the time being, the Soviets are ahead of us in some spectacular aspects of rocketry, just as we are ahead of them in many other *more important* technological areas. We would be totally unrealistic to expect that at any given time, we should be superior to the USSR *at every point* on a broad scientific and technological front. We must accept the fact that the Soviets will temporarily be ahead of us in certain areas, which will vary from time to time, he stated.

Our satellites, launched with the comparatively small rocket boosters derived from our earlier short-range missiles, and equipped with sophisticated instrumentation, have already produced major scientific accomplishments in outer space. The point is that the Russian scientists, who also made important discoveries in outer space, cannot claim supremacy in outer space sciences.

If we separate civilian space technology from military missiles, we can wonder whether our insistence on space superiority is of overriding importance. The unfortunate aspect is that space exploration has caught the public imagination to an extent that gives the Soviet achievements more importance than they rightfully deserve. The public reaction, both here and abroad, has been fostered by the Soviet propaganda machine. Discounting the emotional and political factors involved, our concern about space exploits might be questioned on the grounds of reason and logic, when viewed in the over-all competition for intellectual leadership in science and technology, he said.

There is an essential distinction between science–the understanding of man and the world he lives in–and technology, the application of this understanding to the needs of man. It may be said that scientific research enriches our understanding, while development and engineering give us the new things that are so vitally important for our material welfare and progress. In the public mind these matters are badly mixed up. If this misconception becomes ingrained, both science and technology will suffer.

A dictionary defines science as knowledge obtained by study and practice. This definition applies equally well to technology. But both are different. It is small wonder then, that current Russian successes in rocket propulsion, and some other technological skills (dazzling though they may be) are often described by the press as "scientific" superiority–and thus they are given deeper significance than they deserve. To stress differences between science and technology is not to imply value judgments. Each is equally necessary to our society. But we cannot hope to devise an adequate technology without first having a sound foundation of basic science on which to build it, he concluded.

SNAFU in scientific translation program

"The main trouble is duplication of translations . . . Another short-coming is a lack of skilled and systematic selection of foreign material fit for translation . . . The existing system does not provide a high quality of translation . . . The majority of the offices do not have the necessary cadres of highly skilled translators, especially where uncommon languages are concerned . . . As a result of the high cost of a single copy of a translation, translated m. terials become accessible only to 'chosen' organizations possessing sufficient funds for them." A blast from Washington? No–from an article by Ye. Paskhin, Senior Scientific Editor of the Department of Translations of the Affiliate of VINITI (All-Union Institute of Scientific and Technical Informations, Soviet Union), printed in Komsomol'skaya Pravda, 1959.

Chemical industry sales still pointing up

Continued gains forecast for 1960 in all sectors of the chemical industry according to MCA's year-end survey.

Despite the steel strike, the U.S. chemical industry chalked up sales gains in 1959 over the previous high in 1957, according to the Manufacturing Chemists Association. In round figures, the increase amounted to about $1.6 billion, for a 1959 total of around $25 billion.

Capital expenditures for new plant and equipment are estimated by MCA at $1.248 billion in 1959, compared with $1.320 billion in 1958, and $1.724 billion in 1957.

Profits up

Profits after taxes for the first half of the year (1959) amounted to 8.1% of sales, compared with 6.6% in the first half of 1958, and 7.8% in the first half of 1957. At the same time the wholesale price index remained relatively steady, standing at 110 in October, while comparative figures for 1958 and 1957 were 110.2 and 110.4 respectively.

Price trends for chemicals were somewhat mixed. Naphthalene, because of coke-oven shortages during the steel strike, exhibited a sharp price rise. Nitrogen fertilizer materials were up to some extent, while synthetic rubber showed a 47% increase in export sales, as of July, attributed to the recent price increase for the natural product.

Price of aluminum sulfate was down, as were ascorbic acid and riboflavin. Other downward price changes included maleic anhydride and fumaric acid.

Production figures for chemicals and allied products are up—the index averaged 207 for the first three-quarters of 1959, as compared to an average of 184 for 1957 and 1958 combined. Production in the chemical industry is said to have doubled in the past ten years.

Assets at record high

Total assets for the chemical and allied products industries stood at $22.468 billion at the end of the second half of 1959. This is reported to make the industry the fourth largest in the country, exceeded only by petroleum refining, primary metals, and transportation.

Employment in the chemical industry averaged 844,600 during the first 10 months of 1959, above the 1958 average of 820,900, and closely approaching the 1957 high of 844,800.

Continued overall gains are forecast by MCA for 1960. Some industry spokesmen are said to predict that 1960 sales may reach as high as $28 billion.

Breakthrough expected in auto exhaust control devices

"A minimum of three effective auto exhaust control devices may well be unveiled in 1960," says W. L. Faith, managing director of the Air Pollution Foundation, San Marino, Calif. These may or may not include Thompson-Ramo-Wooldridge's direct-flame afterburner, Houdry's catalytic converter, and Ford Motor's catalytic muffler, adds Faith.

Cornell Chem. Eng. grads trail physicists in starting salaries

Engineering physics graduates from Cornell in June, 1959, lead in starting salaries, according to a recent survey, with an average of $570—one graduate is being paid $640. Second highest paid group are the chemical engineers, with an average monthly wage of $543, and a high of $600. Next in descending order came the metallurgicals, the electricals, the agriculturals, the mechanicals, and the civils.

Ford Foundation grants in engineering

The University of Michigan has been granted $1,175,000 by the Ford Foundation for use in science and engineering. Major portion of the grant, $900,000, will go to support a U-M experimental program on use of high-speed computers in engineering education.

Scientists, engineers unhappy

In a survey made by Opinion Research, 72% of scientists and engineers interviewed complained that management misuses their talents, 71% said their companies force them to overspecialize, 80% claimed they were underpaid, and 67% thought that getting ahead in management involves more politics than knowledge.

Out of chaos—creativity

"A state of imaginative, muddled confusion" seen as necessary prelude to scientific discovery.

How to assure creative work in an industrial organization? "Latch on to creative people, and then organize them in such a way as to keep them from quitting." It's as simple as that, said skeptical, down-to-earth David Langmuir, director of Thompson-Ramo-Wooldridge's Los Angeles Research Laboratory, during a symposium on *Organization for the Utilization of Creativity,* at the recent A.I.Ch.E. Annual Meeting in San Francisco. In a more serious vein, Langmuir's prescription was "to define the problem, assign the needed skills, and then make the people care about the problem."

What is creativity? "Creative behavior is the whole action of developing in any new way that vast complex of subjective structures which constitute that vision of the world by which we live," said Brewster Ghiselin, poet and literary critic, now professor of English at the University of Utah.

The negative approach

Organizing to Suppress Creativity was analyzed in detail by Harcourt C. Vernon of DuPont. His advice on the best way how *not* to do the job.

- Remove all sources of self satisfaction.
- Destroy individual dignity.
- Create an atmosphere of confusion in the organization.
- Maintain a state of turmoil as to status and responsibility.

Many efficient techniques have been worked out and are in common use for the suppression of creativity, pointed out Vernon. For instance, he said, one of the best is to give credit to a group instead of to the individual who actually was responsible for the work.

Out of muddled confusion

"Creativity flourishes," opined Langmuir, "when people working on a problem are in a state of imaginative, muddled confusion. I subscribe to the view that a crucial phase of many scientific discoveries occurs when the picture is clear to no one." In somewhat the same vein, Thomas H. Chilton, moderator of the panel, summed up the evidence — "In development we know where we are and whither we are going. In research, we know neither, and sometimes come upon a new world."

However, in spite of widely divergent views as to the nature of creativity, and the techniques of promoting it, it was agreed that more and more industries are paying out cold hard cash for "creativity research," and are assigning personnel to such projects.

New U. S. polypropylene producer

Longview, Texas, will be site of a 20 million pound per year polypropylene plant to be built and operated by Texas Eastman, a division of Eastman Kodak. Construction start is slated for early 1960, full production is scheduled for mid-1961.

Private nuclear fuel processing to be studied

A group of five electric utilities and one chemical company, organized as Industrial Reprocessing Group, have pooled their efforts to study the technical and economic feasibility of design, construction, and operation of a privately-owned facility for processing of spent nuclear fuels. The utilities are: Commonwealth Edison, Chicago; Consolidated Edison, New York; Detroit Edison, Detroit; Northern States Power, Minneapolis; Yankee Atomic Electric, Boston; the chemical company is the Davison Chemical Division of W. R. Grace.

Soda ash plant for Korea

The Republic of Korea moves nearer to chemical self-sufficiency with the signing of a loan agreement for a $5.6 million soda ash plant. Funds will come from the U. S. Development Loan Fund, owner and operator of the plant will be Orient Chemical Co.

Coal tar chemicals demand increasing

Coal tar distillation capacity will be upped at two U. S. Steel plants: Tennessee Coal & Iron Division's Coke and Coal Chemical Works in Fairfield, Alabama, and U. S. Steel's Clairton Works near Pittsburgh, Pa.

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U.S.I. CHEMICAL NEWS

Jan. ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1960

U.S.I.-International Formed To Serve Markets for U.S.I. Polyethylene Abroad

A new European company has been formed by National Distillers (U.S.I.'s parent corporation) to handle the overseas sales of PETROTHENE® polyethylene resins, and to provide technical service and help in developing markets to customers for polyethylene. The new unit will be called U.S. Industrial Chemicals Co. — International, Division of Sales and Development Company of National Distillers and Chemical Corporation—(International) S.A. Temporary headquarters were opened in September at Kirchenstrasse 13, Zug 1, Switzerland. Permanent headquarters and laboratories will be constructed in Baar, Canton of Zug.

A customer service laboratory will be an integral part of the new company. It will be completely equipped with processing and test equipment designed to meet European standards and operating conditions. The laboratory will be used to demonstrate processing techniques and for research and evaluation studies to help its customers develop new end-use markets and produce improved products. The laboratory will also include polymer testing equipment to insure product quality. The laboratory will service markets in the European countries, including the United Kingdom. Mr. Howard W. Woodham is the Manager of the new Technical Service Laboratory.

Sales Manager of U.S.I.—International is Mr. Kenneth E. Cosslett, who has been U.S.I.'s Assistant Export Manager. According to Mr. Cosslett, U.S.I.—International's PETROTHENE resin sales will be made through established representatives in European countries. The new company will be a supporting unit to help these representatives provide the close technical assistance which the polyethylene market demands.

Woodham

Cosslett

Ruthenocene and Osmocene Found to Have Aromatic Character, Like Ferrocene

Two more organometallic compounds are reported to behave like aromatics, although the compounds from which they are derived are completely nonaromatic. In this re-

MORE

Methionine Stressed for Cosmetic and Pharmaceutical Use

New Developments Summarized and Current Applications Reviewed in Paper Given at TGA Meeting

At the December meeting of the Scientific section of the Toilet Goods Association in New York, Dr. Harry J. Prebluda of U.S.I. and Dr. Irwin Lubowe of the New York Medical College spoke on the growing uses of methionine in drug and cosmetic formulations. Methionine is an essential amino acid containing sulfur.

Increased knowledge of methionine's reactions and functions in the living organism has stimulated a considerable amount of interest in the compound. Clinical studies following up on basic biochemical research have pointed to new uses for synthetic DL-methionine in pharmaceuticals and cosmetics. U.S.I. has been a pioneer in the development and use of synthetic DL-methionine by the animal feed and pharmaceutical industries.

Topical Applications

Clinical trials have been conducted with methionine and its derivatives in the topical treatment of various cutaneous diseases with great success. Data on the rate and extent of methionine absorption through the skin indicates nearly half the efficiency of oral feeding. This means that some of the polyfunctional properties of methionine can be utilized by formulators of cosmetics, toiletries and topically applied medications. Commercial preparations containing DL-methionine along with other ingredients for topical use are presently appearing in this country and abroad. Aerosol sprays are also being explored.

A therapeutic compress containing methionine has been formulated which has proven very effective in the early treatment of infectious and eczematous dermatitis. There have been several favorable reports on the value of methionine for wound healing in protein depleted animals and humans.

MORE

World's largest zirconium ingot, 13,200 lbs., gets surface examination at Niles, Ohio, plant of Mallory-Sharon Metals Corporation (owned one-third by U.S.I.). Ingot was melted from zirconium chunklets produced by company's exclusive sodium reduction process. Melting of giant 30-inch ingot is regarded as significant achievement, since cost of strip and sheet products is directly affected by ingot size.

Polyurethane Foam Now Used in Bone Surgery

According to recent reports, surgeons can now "glue" broken bones, permitting patients to move a fractured limb while it is healing. Polyurethane foam is the material used, and it has already been tested successfully in hundreds of cases of serious fracture demanding reduction by surgery.

The foam is prepared right at the operating table from sterilized prepolymer and activator, then poured into place by the surgeon. It hardens rapidly, and the patient can move the limb within a few hours. Patients have walked on broken legs so treated in two to seven days after surgery.

The polyurethane foam is quickly replaced by new bone which grows through and around it. No toxic reaction has been reported.

New Data Sheet on Caustic Soda Just Issued by U.S.I.

Specifications, properties, applications and shipping information for caustic soda are detailed in a new data sheet now available from U.S.I.

The material, which U.S.I. ships as commercial grade 50% liquid in tankcars, tank trucks and barges from two plants at Huntsville, Alabama, is used primarily in the manufacture of chemicals, rayon and film, pulp and paper, petroleum derivatives, cleansers, textiles and soap.

The data sheet can be obtained from U.S.I. sales offices or from the Chlorine and Caustic Soda Sales Department, U.S. Industrial Chemicals Co., 99 Park Avenue, New York 16, N.Y.

CONTINUED

Methionine

Oral Use

Many cases of chronic peptic ulcer have been treated with methionine, with good clinical healing results in 80% of the patients. The addition of methionine to infant oral formulas is effective for clearing up cases of diaper rash. Similarly, methionine has been used orally for urine odor control with older patients in hospitals and other institutions. Methionine intake at high levels has been used in the treatment of stubborn urinary tract infections. Stable chemical reaction products from organic acids and methionine derivatives have been prepared which show clinical promise for a series of non-toxic wide-spectrum urinary antiseptics.

Methionine has been used in formulations for treating coronary artery disease in humans. The material also seems to protect biological systems against natural or nuclear radiation. More recently, methionine has been tried in the treatment of schizophrenia in a European psychiatric clinic with excellent results. American workers have already started to explore the possibilities of using methionine by itself or in combination with recognized tranquillizers for the treatment of mental disease and emotional depression brought about by impaired nitrogen metabolism.

The technical presentation before the TGA was documented with 48 references. Reprints can be obtained from U.S.I. on request.

CONTINUED

Organo-metallics

spect they are like ferrocene (dicyclopentadienyliron) which appears to have aromatic reactivity although it is derived from non-aromatic cyclopentadiene.

The materials are ruthenocene (dicyclopentadienylruthenium) and osmocene (dicyclopentadienylosmium), prepared from ruthenium trichloride and osmium tetrachloride plus cyclopentadienylsodium which is a reaction product of cyclopentadiene and metallic sodium. Both ruthenocene and osmocene undergo substitution reactions that are characteristically aromatic. They react with acyl chlorides in the presence of aluminum chloride in a way typical of aromatic Friedel-Crafts reactions. They can be metalated with n-butyllithium to give (after carbonation and hydrolysis) mono- and dicarboxylic acids.

Because all of these metallocenes participate in the Friedel-Craft reaction, it has been possible to prepare novel compounds containing two different metals—ferrocenyl ruthenocenyl ketone, for example.

New Polyethylene-Lined Drums Designed to Ship Liquid Chemicals

A new type of polyethylene-lined drum now available to the chemical industry has an outer pack which consists of wood members reinforced with double-dipped, galvanized steel binding wires and staples. This exterior is said to be corrosion-resistant, and to make the drums lighter, more durable and less expensive than the usual combinations of steel and polyethylene.

The drums have passed MCA-ICC tests for regulated liquids, and can now be used for any liquid safe in polyethylene. This includes corrosive, inflammable and toxic materials.

Photo courtesy Delaware Barrel & Drum Co.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Amino-acid resins—a series of ion-exchange resins specially prepared for separation and analysis of amino acids—are now on market. Available in two types for use with fraction collectors or amino-acid analyzers **No. 1550**

Plastics safety handbook now being sold is first such volume devoted entirely to safety ever to be published for plastics processing industry. Many industry processes are specifically treated, giving latest safety methods. **No. 1551**

New portable hydrocarbon detector gives rapid analysis of total organically bonded carbons in gases, with sensitivity better than 0.1 ppm. Can monitor air pollution or lower explosive limits, detect leaks or impurities in systems. **No. 1552**

New catalog offers reprints of technical journals and books long out of print but in great demand. Reprints are reproduced in book form by offset process, and are sold both paper-bound and cloth-bound. **No. 1553**

Mobile vacuum system can now be obtained which is claimed to produce any desired moderate vacuum (250 mm to 0.5 mm) and hold it within ±0.2 mm, in an airtight system. Plugs into any 115-volt, 60-cycle, a-c outlet. **No. 1554**

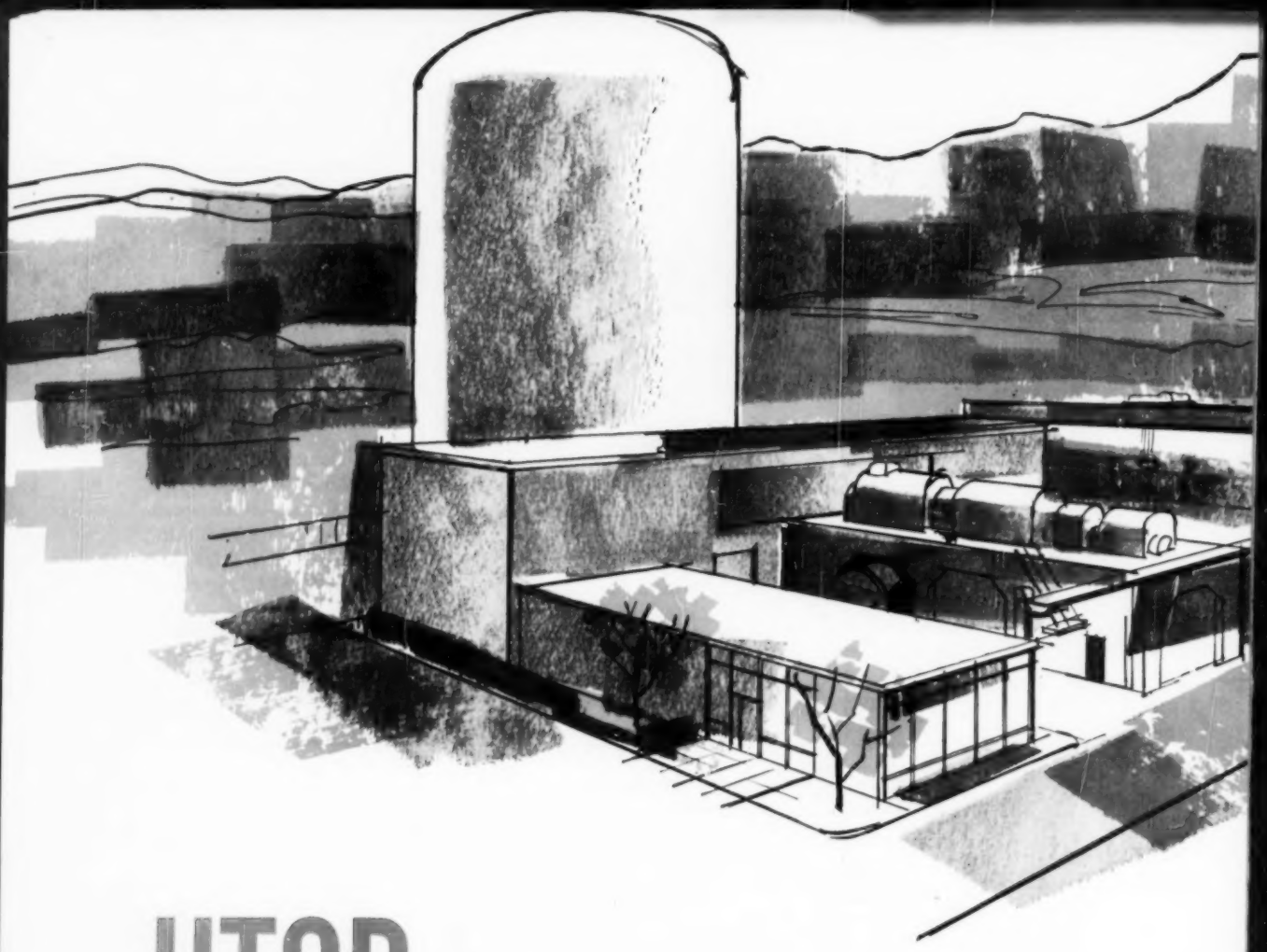
For painting and decorating polyethylene, new flexible lacquer has been developed. Said to be durable, chip-proof, will not come off with handling. No special treatment of polyethylene needed to make lacquer adhere, it is claimed. **No. 1555**

Measurement of chlorine-in-air in concentrations from ½ to 20 ppm can now be accomplished with new field detector kit. Employs aspirator bulb to draw samples across detector tube of silica gel. Reaction yields blue stain on gel. **No. 1556**

English translations of Crystallography, a bi-monthly publication of the USSR Academy of Sciences, can now be purchased. Offers experimental and theoretical papers on crystal structure, growth, and other phases of the subject. **No. 1557**

PTH (3-phenyl-thiohydantoins) derivatives of amino acids being offered as tools in protein and peptide structure determinations. Used as standards and for comparisons when applying Edman method to study of protein structures. **No. 1558**

New automatic recording vacuum balance can weigh samples in air or inert gases, at atmospheric or reduced pressures, at room or higher temperatures, on balance pan or suspended below balance in a furnace. **No. 1559**



HTGR/NOW IN ENGINEERING PHASE

The High Temperature Gas-cooled Reactor (HTGR), now under development at General Dynamics Corporation's General Atomic Division, has as its promising goal an important short cut to the nation's objective of truly economic nuclear power.

A prototype HTGR plant designed for 40,000 KW(E) is now under development for Philadelphia Electric Company and the High Temperature Reactor Development Associates, Inc. The high performance HTGR system — the result of an extensive development program at General Atomic during the past three years — embodies the following important design characteristics to achieve economic nuclear power:

1. Modern steam conditions of 1000° F and 1450 psi.
2. A helium gas outlet temperature of 1380° F resulting in an economical and compact heat exchanger system.
3. Fuel burnup of the homogeneous UThC fuel in the 50,000-100,000 MWD/ton range.

The important design features which make it possible to achieve these characteristics include the HTGR's unique graphite fuel-moderator elements, which permit operation at very high temperatures.

Work in progress at General Atomic's John Jay Hopkins Laboratory in San Diego, Calif., will by 1963 result in the completion of construction* of the prototype HTGR plant at Peach Bottom in York County, Pa., on the system of the Philadelphia Electric Company. Associated with the Philadelphia Electric Company in the project are 52 other utility companies comprising the High Temperature Reactor Development Associates. This is the largest and most widely representative group of utilities to support a single nuclear power project thus far in the United States.

*Bechtel Corporation is prime contractor-engineer constructor for the plant, with the nuclear steam supply system designed and supplied by General Atomic Division.

Member companies of High Temperature Reactor Development Associates include:

Alabama Power Company
Arizona Public Service Company
Arkansas Power & Light Company
Atlantic City Electric Company
Baltimore Gas and Electric Company
California Electric Power Company
Central Illinois Electric and Gas Company
Central Illinois Light Company
Central Illinois Public Service Company
Central Louisiana Electric Company
Central Power and Light Company
Cincinnati Gas & Electric Company
Cleveland Electric Illuminating Company
Delaware Power & Light Company
Detroit Edison Company
Gulf Power Company
Gulf States Utilities Company
Hawaiian Electric Company, Ltd.
Idaho Power Company
Illinois Power Company
Iowa Public Service Company
Kansas City Power & Light Company
Kansas Power and Light Company
Kentucky Utilities Company
Louisiana Power & Light Company
Mississippi Power Company
Mississippi Power & Light Company
Missouri Public Service Company
Montana Power Company
New Orleans Public Service, Inc.
New York State Electric & Gas Corporation
Niagara Mohawk Power Corporation
Pacific Gas and Electric Company
Pacific Power & Light Company
Pennsylvania Power & Light Company
Philadelphia Electric Company
Portland General Electric Company
Potomac Electric Power Company
Public Service Company of Colorado
Public Service Company of New Mexico
Public Service Company of Oklahoma
Public Service Electric and Gas Company
Puget Sound Power & Light Company
Rochester Gas and Electric Corporation
St. Joseph Light & Power Company
San Diego Gas & Electric Company
Sierra Pacific Power Company
Southern California Edison Company
Southwestern Electric Power Company
United Illuminating Company
Utah Power & Light Company
Washington Water Power Company
West Texas Utilities Company

GENERAL ATOMIC
DIVISION OF **GENERAL DYNAMICS**

Openings For Engineers In Nuclear Reactor Design

Rapid expansion of the High Temperature Gas-cooled Reactor and other major programs at General Dynamics' General Atomic Division has created increased engineering activity leading to openings, including senior positions, in reactor design and development.

In the important area of nuclear engineering, immediate openings exist for men qualified to perform thermal analyses of reactor cores . . . reactor design neutronic calculations . . . analyses of reactor and system controls . . . structural design of reactor components . . . and the design of mechanisms such as control drives and fuel charging systems associated with the reactor. There are also openings in the HTGR program for qualified metallurgists, physicists, chemists and chemical engineers, materials specialists, mathematicians, and programmers.

Inquiries are also invited from senior men qualified to conduct studies of new applications of nuclear energy in the power generation, transportation, space propulsion, and chemical fields.

Besides HTGR, other programs presently in progress at General Atomic include the MGCR gas-cooled reactor and closed-cycle gas turbine system for merchant ship propulsion . . . TRIGA reactors for research, training, and isotope production . . . small nuclear power systems . . . test reactors . . . nuclear power for space vehicles . . . direct conversion of heat to electricity . . . and research in controlled thermonuclear reactions.

For further information on these openings, write: Manager of Personnel, General Atomic, P.O. Box 608-S, San Diego 12, California.

Reactor Core — High Temperature Gas-cooled Reactor

Washington scope

Food Chemicals Act upsets industry

THE STATE OF CONFUSION that existed at Thanksgiving time, concerning contamination with aminotriazole that almost removed the traditional cranberry from the national Thanksgiving menu, was only a flurry compared to the state of near panic that now exists among manufacturers who produce products that must be cleared under Public Law 929 prior to March 6.

The problems involving the elimination of penicillin in milk and diethylstilbestrol in poultry and beef are pipsqueak compared to the herculean task of clearing for production products used in handling, wrapping, storing and processing foods in compliance with the very strict dictates of this new law, which amends the Federal Food, Drug and Cosmetic Act of 1938. The problem is amplified and further confused by the fact that potable water and "drugs" used as food supplements are covered by this amending legislation, whereas drugs taken internally or used externally apparently are covered only by the stipulation of the original Act of 1938.

Stripped of its legal jargon, Public Law 929 requires that everything used in the food industries that comes in contact with the food must be shown to be free of materials that will jeopardize the public health or which are known to induce cancer in man or in other animals, regardless of amounts ingested. Secretary of Health, Education and Welfare, Flemming said at his news conference on December 10, "Any chemical now used in foods which is not generally recognized by appropriate experts as safe for its use will have to be discontinued as of next March 6, unless a clearance has been obtained for it or an extension of time granted for obtaining a clearance."

Many trade associations, whose members' products are affected, have suddenly become alarmed by the flood of inquires from members' customers requesting assurance that this, that, or the other product or device is cleared under the law. As George B. Larrick, Commissioner of Food and Drugs, stated at the Symposium on Chemistry

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Washington scope

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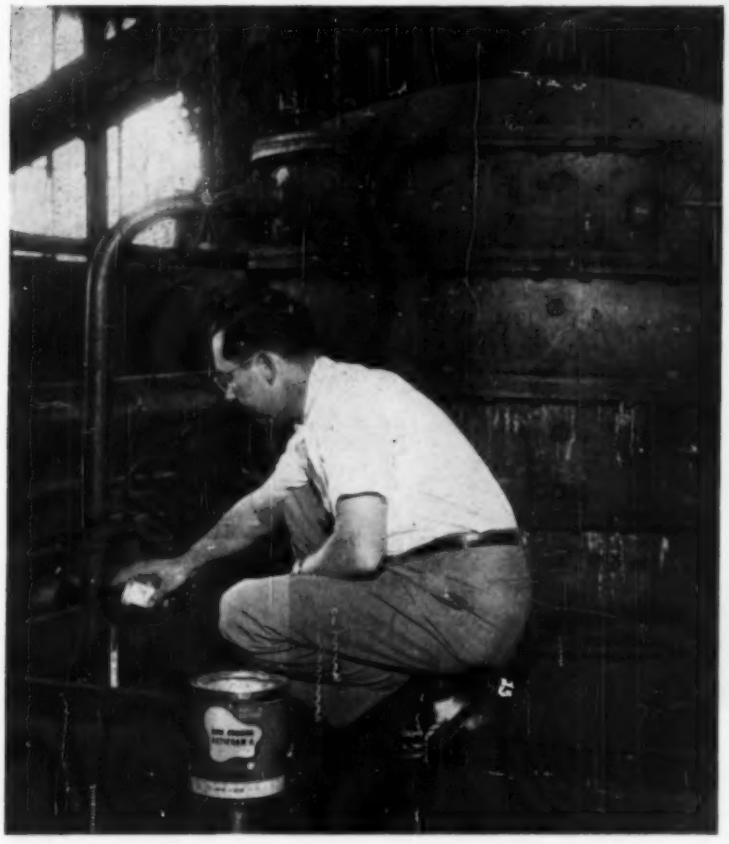
and Engineering in the Food Processing Industry in Chicago, the substances covered by the Food Additives Amendment are those additives not generally recognized by competent experts as having been adequately shown to be safe under the conditions of their intended use. The amendment covers substances that are added intentionally in foods as well as those that may reasonably be expected to become a component of food incidentally or to affect its characteristics adversely. Use of ionizing radiation in food processing is covered by the amendment and will need to be established as safe before commercial use. Substances commonly used in food before January 1, 1958, and generally recognized as safe because of experience based on such use, are exempt from the law. Thus, a great many ingredients will not have to go through the clearance procedures of the bill.

The Manufacturing Chemists Association has considered the matter informally in a meeting here in Washington with Larrick. Members of this association seem to be taking their problems in stride, due, probably, to their long time acquaintanceship with F.O.A. procedures. M.C.A. anticipates no such panicky feeling among its membership as now apparently exists with producers of items made of compositions that include curing agents, softeners, antioxidants, etc.

Knowledgeable people in the petroleum industry that provide waxes and other materials primarily for food wrappings and food containers, cautiously admit that to say they are confused is putting it mildly. The American Petroleum Institute has a committee that is currently wrestling with the problem.

There is probably no cause for alarm on the part of manufacturers who are producing materials, devices, or equipment coming within the scope of Public Law 929, and who are sincerely desirous of complying with its requirements in regard to clearing their products as acceptable before the March 6, 1960, deadline. As stated by Secretary Flemming at his news conference on December 10, 1959, a detailed statement of conditions for obtaining an extension will be published in the Federal Register. Such extensions will be granted, however, only where there is no evidence that the public health is endangered by so doing. —*J. L. Gillman, Jr.*

Costs Go Down with Foam



IN VARNISH COOKING

Job-proved as fastest and most effective for all processing operations, Dow Corning silicone defoamers are available in different forms for different systems. Why not make tests on the materials that are giving you foam problems?

A generous trial sample is yours for the asking. Write for this FREE SAMPLE, giving an indication of your problem and the type of system — oil, aqueous, non-aqueous, food product or other. Address Dept. 2301 for prompt reply.

Silicone Defoamer Beats Down Foam ...Defeats High Maintenance Cost

The chief engineer of a southern chemical plant periodically met real bugbears—foam boil-overs in a methanol-wood oil fractional distillation system. Such occurences meant shutting down the still, while over 600 man hours were spent putting the unit back in condition.

That was before testing silicone defoamers. Now, foam's completely eliminated simply by adding only 5 parts per million of Dow Corning Antifoam A. Boil-over clean-up man hours are nil. The chief engineer champions this silicone defoamer as the most effective system — says, "Without it, I'd simply go crazy."

If foam is fouling up your processing, putting you behind schedule and leaving you with too high a ratio of waste material, chances are you can lick foam once and for all — realize noteworthy savings through the use of Dow Corning silicone defoamers. Easy to use and economical, these silicone defoamers are widely used to overcome foam problems in processing varnish, paints, adhesives, asphalt, textile dyes, petrochemicals, foods and many other products.

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For more information, turn to Data Service card, circle No. 13

Authors

from page 12

development division. Braconier took part in the Gordon Research Conference in 1957, when he presented a paper on the acetylene processes of SBA. Leroux has a degree from the University of Belgium in 1947, and did graduate work at California Institute of Technology.

GROVER

BRACONIER

H. C. Schutt (*High Purity Acetylene via the Solvent Extraction Route*) has a consulting engineering firm in Boston. Educated in Germany, he has lived in the United States since 1928, engaged much of the time in the development and design of apparatus for the oil refining and petrochemical industries. Schutt has published articles on high temperature pyrolysis and on various phases of ethylene recovery.

SCHUTT

PIESTER

L. W. Piester (*Hydrogen Sulfide Desorption from NaCl Brine*) first worked on this project several years ago. He is currently director of development at Columbia-Southern Chemical's New Martinsville, West Virginia, plant.

A. J. Barduhn and **B. E. Kurtz** (*Compacting Granular Solids*) are both residents of Syracuse, New York. Barduhn is on the chemical engineering faculty at the University, and Kurtz

BARDUHN

KURTZ

was a student there in 1957, and again in 1959. The latter has done extensive work on the compaction of granular

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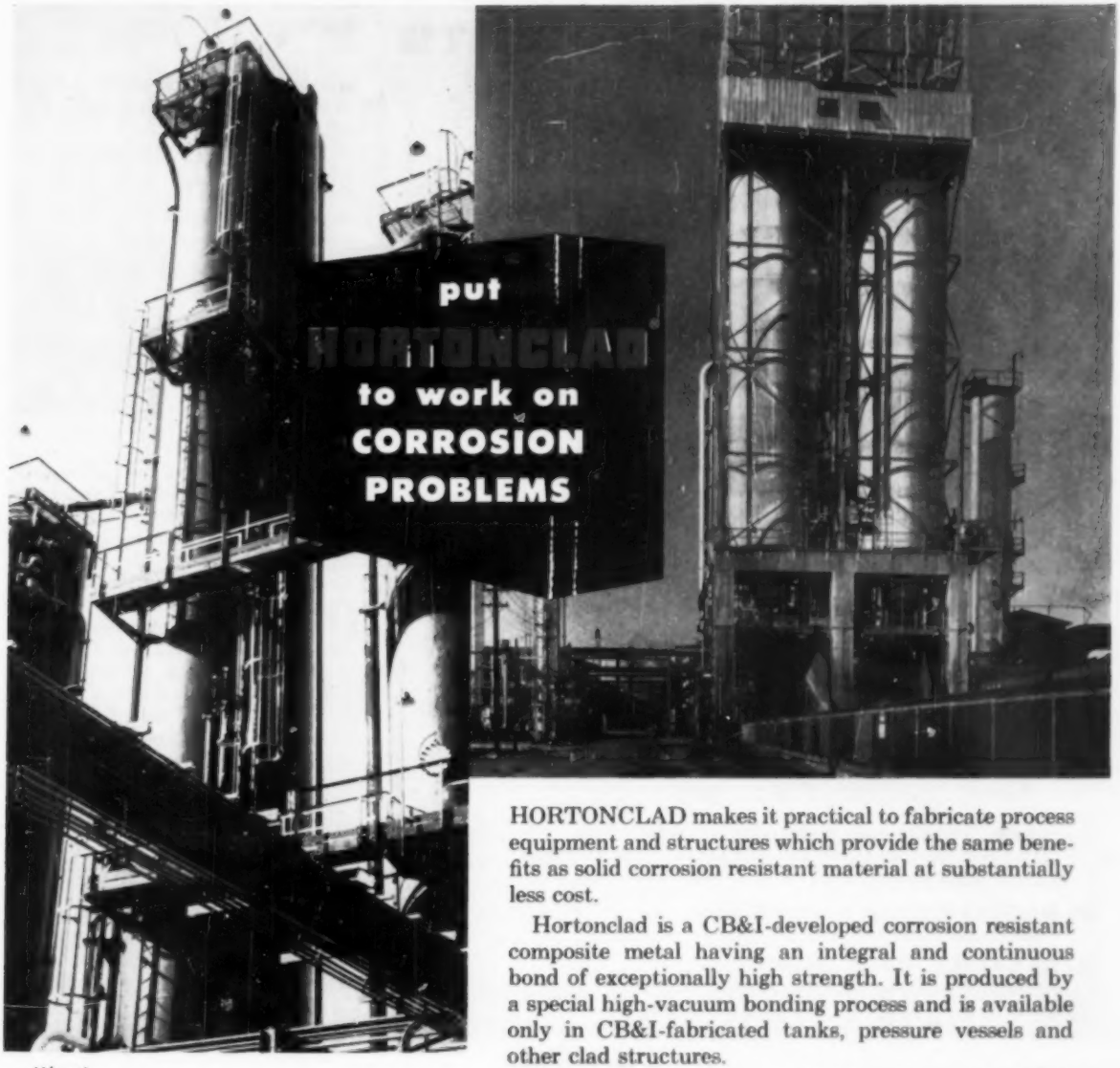

(Above)

ABSORBER TOWER at a Louisiana chemical company has stainless steel Hortonclad shell. Thickness of backing and cladding is 1¼ inches.

(Right above)

COKING CHAMBER at a Kansas refinery uses 405 stainless steel Hortonclad backed by A205 Grade A moly steel.

HORTONCLAD makes it practical to fabricate process equipment and structures which provide the same benefits as solid corrosion resistant material at substantially less cost.

Hortonclad is a CB&I-developed corrosion resistant composite metal having an integral and continuous bond of exceptionally high strength. It is produced by a special high-vacuum bonding process and is available only in CB&I-fabricated tanks, pressure vessels and other clad structures.

Silver, stainless steels (both chromium and nickel) nickel and alloys such as Monel, Inconel, Hastelloys B and F and a variety of other alloys may be employed in the Hortonclad process. Write our nearest office for a copy of the CB&I bulletin which describes:

. . . the benefits of HORTONCLAD

1. **Corrosion resistance**
2. **Economy of design**
3. **Uniform thickness of clad and backing plate**
4. **Integral and high strength bond**
5. **Wide selection of cladding materials**
6. **Clean contaminant-free surface**

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CB&I

C41C

For more information, turn to Data Service card, circle No. 70

Authors

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solids at Solvay Process Division, Allied Chemical, as part of a company project. Barduhn, in addition to his teaching, also serves as consultant at Carrier Corporation.

C. F. Gerald and **H. W. Grote** (*Alkylating Aromatic Hydrocarbons*) have

GERALD

GROTE

worked together on this problem at Universal Oil Products, and this is the third paper in a series on the subject. Gerald is in the Engineering Research and Development Department while Grote is manager of the Petrochemical Process Sales Department.

H. R. Linden and **J. M. Reid** (*Acetylene-Ethylene Via Thermal Cracking*) are both specialists in the field of gasification. Linden is research director of the Institute of Gas Technology, while Reid is supervisor of catalytic and thermal cracking, and oil gasification research programs. Linden has

LINDEN

REID

been with the Institute of Gas Technology for 12 years. Author or coauthor of over 40 published technical papers, he holds several patents in gas production and processing. Reid has also published several works in the field of gasification and petrochemical research.

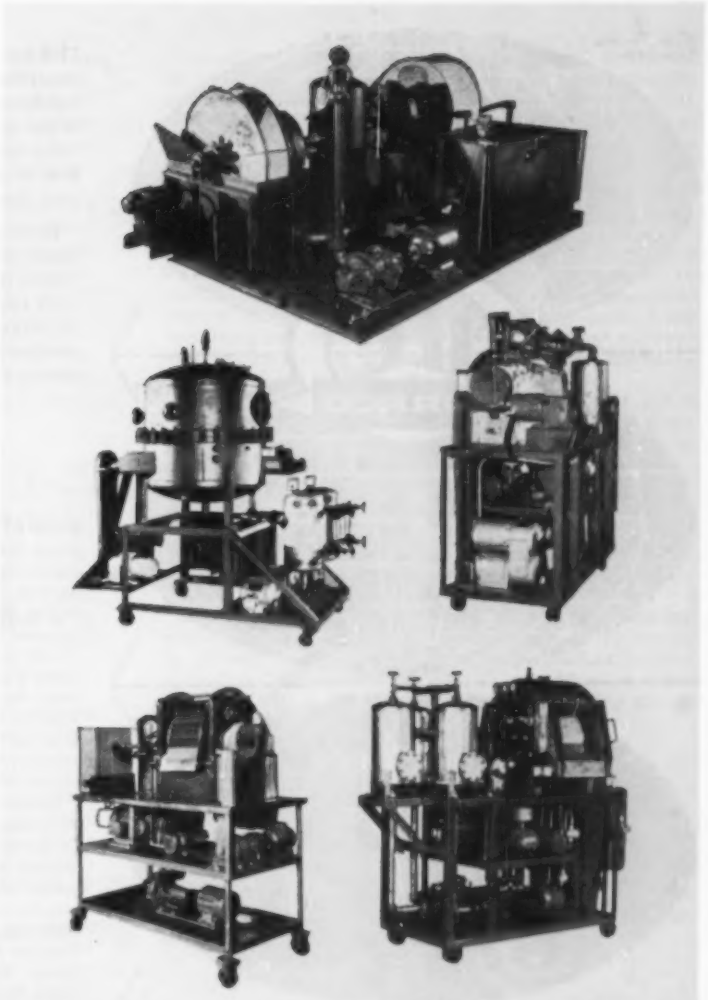
L. Berg and **D. E. Atkinson** (*An Economical Char Process: How Soon?*) are on the chemical engineering faculty of Montana State College, Bozeman, Montana. Much of the work on the M.S.C. Char Process was done at the Engineering Experiment Station of the college, where a pilot plant was set up in 1954.

Correction

In the article *Scale-up of Mixer-Settlers* by A. D. Ryon, et al, which appeared in the Oct. 1959 issue of CEP, the captions for Figures 4 and 6 were transposed.

Now!

You Can Either Rent or Buy



Eimco Laboratory and Pilot Plant Filters

For many chemical processors having only temporary need for pilot scale equipment, Eimco's rental option for laboratory and platform filters offers many important advantages.

The many variable factors in any liquid - solids separation — the unknowns — can be studied. Various discharge and cake treatment accessories can be tried out. Optimum operating conditions can be established before investments are made in full scale equipment.

Eimco pilot plant filter stations arrive complete, ready to get into operation in your circuit. Receivers, vacuum pumps, filtrate pumps, blowers, motors, piping, and control panel are mounted on a structural steel platform . . . each a compact, mobile unit.

Laboratory and pilot plant filters are available for any filtration method. Part of the rental charge may be applied to the purchase cost if the user has a continuing need for the filter.

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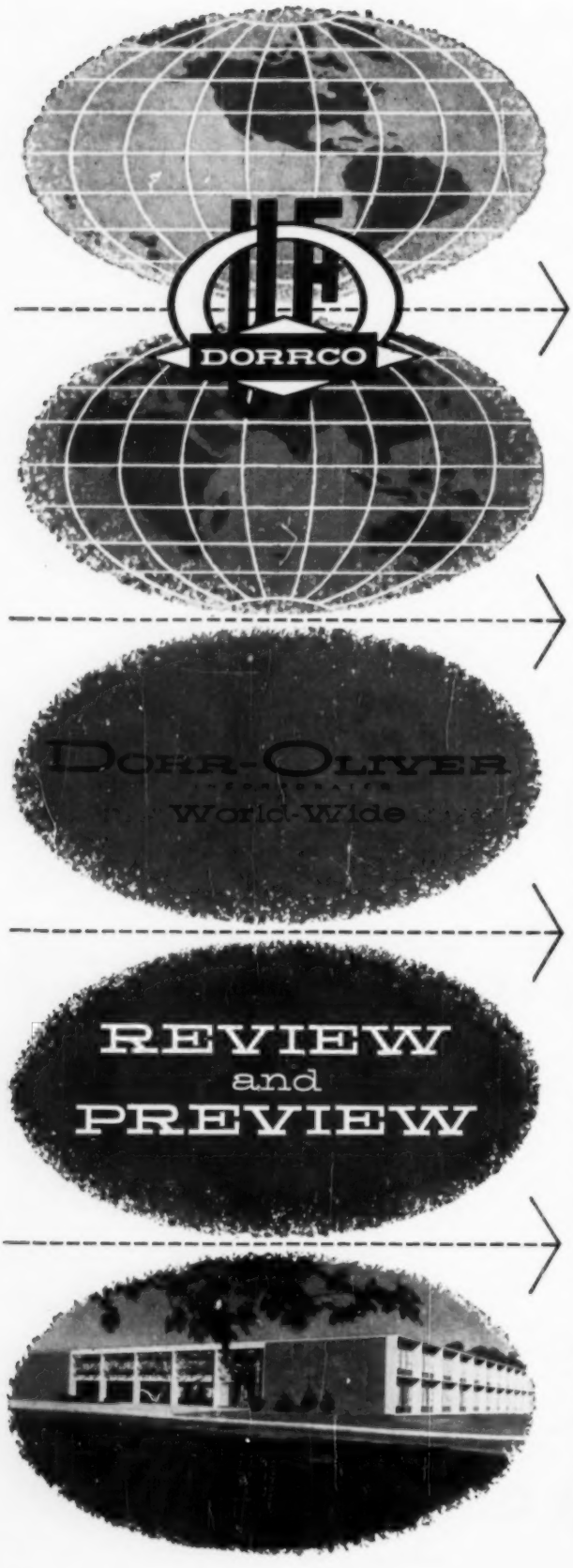

1959 has been a paradoxical year. With the public press reporting good business for the country as a whole, it has taken a discerning student to discover that the part of the economy relating to capital goods has only bettered to a modest degree. This fact, plus the low carryover of orders from 1958, caused us to have an unhappy year financially.

However, with the modest but positive increase in business in the U.S.A. and the substantial increase in orders for most of our overseas areas, we look forward with confidence to 1960. Improvement of efficiencies in all internal departments has also been positive and is continuing both as to costs and the time it takes to do things. This naturally will be beneficial to our customers.

SANITATION—Once again this segment of our operations has played a dominant role in our worldwide business during the past year. Orders were placed with us and our subsidiaries to serve larger centers of population such as Trenton, New Jersey; New York City; Bagdad, Iraq; Chicago, Illinois; and Elizabethville in the Belgian Congo, as well as for smaller municipalities from Pierrefond, Ontario to Albertville, Alabama and from the Villa Carmen housing development in Puerto Rico to Harlingen, Texas. Two large U.S. corporations also will install D-O equipment in treatment plants constructed for a research laboratory in New York State and a West Virginia townsite.

Further proof of widespread acceptance of our newer developments is installation of a SpiroVortex system at Checotah, Oklahoma and of CompleTreator units at industrial plants, recreation centers, housing developments and military sites in the United States. Abroad, our Dutch subsidiary will install one of these units in a concrete rather than steel tank, and the first CompleTreator unit has been purchased in the Philippines. The latter, for a large refinery, represents the first export order for our manufacturing representative in Malaya.

New applications of proven equipment include use of the ODS pump for handling conditioning lime for sewage sludge filtration and fabrication of a plastic sludge filter. Also, development work continues on additional applications of our industrial equipment in the sanitary field.

SUGAR—Orders from new and expanding cane sugar factories in India for RapiDorr Clarifiers and Oliver-Campbell Filters contributed significantly to the business of our subsidiary in that country. And in other locations around the world—Mexico, British Honduras, Egypt, Mozambique and Swaziland, for example—these two units continued to be accepted as standard in the industry. In beet sugar, a British producer purchased First Carbonation Thickeners and Vacuum Filters for two new mills; and two Italian mills will use a total of four Vacuum Filters.

PETROLEUM—A variation of the initial application of the DorrClone Desanding System in fresh water treatment is the desanding of salt water used to recharge wells for secondary oil recovery at a West Coast location. Outside the U.S. our Japanese representative is fabricating filters for use in a catalytic cracking process and our British company will supply oil-water separators for both British and Brazilian refineries. Also of interest is equipment for a pilot plant to recover oil from tar sands.

PROJECT ENGINEERING—This phase of our operations was also particularly active in 1959 as design of phosphoric acid plants to be located in Idaho, Great Britain and Ireland and a phosphoric acid and triple superphosphate installation for Brazil was commenced. Also in the fertilizer field was a contract for process modification of a large British plant.

Late in the year, work was started on design of a large limestone crushing plant for which D-O will also purchase equipment and other materials. Our French subsidiary and domestic company working jointly virtually completed design of a large Yugoslavian copper concentrator. Two smaller but nonetheless significant projects—both including laboratory testing and feasibility studies—involved production of a limestone substitute to be used for self-fluxing sinter in blast furnace operation and the recovery of nickel from waste pickle liquors.

WATER—Conventional pre-treatment equipment will be utilized at D-O supplied water plants for a new steel mill in India, a military camp in Iraq and the municipalities of Wilmington, Delaware; New Castle, Pennsylvania; Saida in Lebanon; and Maracaibo and Naiquata, Venezuela. Next year new PeriFilter systems will go into operation at New Oxford and South Pittsburgh, Pennsylvania and in 1959 a large system with two Hydro-Treator mechanisms went on line treating Midland, Michigan's water supply.

FLUOSOLIDS SYSTEMS—One of the new applications of the FluoSolids System this year has been preheating coarse shale in a special three-compartment reactor to produce light-weight aggregate. A second is drying iron ore before magnetic separation and concentration. Currently, the iron ore industry appears to have other drying applications ideally suited to fluidization. FluoSolids roasters are also under construction for a Canadian smelter where only partial sulfur removal is required.

Projects involving already proven applications have included in 1959 a pyrite roaster for a sulfuric acid plant on Formosa, three systems marketed by our Italian subsidiary for roasting pyrite to produce sulfur dioxide for pulp mill bisulfite cooking liquor and for a large zinc roasting installation in Yugoslavia, a large coal dryer for a Western producer, a copper-cobalt roaster in the Belgian Congo and detergent dryers in the United States.

METALLURGICAL—As in past years our work in this area has involved virtually all of the metallic minerals from gold to iron ore. The latter field has been among the most active with purchase of Sizers and Filters for Canadian washing plants, DorrClone classifiers for desliming prior to flotation and Thickeners, Filters and Pumps for recovery of blast furnace flue dust.

PULP AND PAPER—A new tool for this industry is a novel pressure washing filter. Installation of the first U.S. manufactured unit is being made in a Southeastern pulp mill. Ideally suited to brownstock washing, the unit has a number of advantages from both the operating and installation standpoints.

Recausticizing systems including process flowsheet innovations, such as precoat operation of the Lime Mud Filter and application of a two-compartment White Liquor Clarifier with special feedwell, were purchased for new or expanding mills in Canada, India, the United States, Portugal, Japan, Yugoslavia, Scandinavia and the Philippines.

Around the world the American Saveall continued to be recognized as the major means of recovering paper machine fibers from white water and in the U.S. the largest bleach tower designed to date will soon go into operation. An unusual and interesting application of the Merco Centrifuge is recovery of by-product material used as a drill mud dispersant at a West Coast mill.

CHEMICAL—During the year applications of the Plastic Filter, first introduced in mid-'58, were broadened to include a variety of fine chemical and pharmaceutical separations and washing of acid leach liquors from metallurgical pulps. Also in the realm of new applications is dewatering of various plastics using the Mercone Screening Centrifuge.

As usual, our standard line of equipment played a major role in a great number of Italian chemical plant expansions and in large new or expanded facilities in France, Germany, Spain, Mexico and here at home.

FOOD PRODUCTS—Successful application in 1958 of the Mercone-Precoat Filter combination for apple juice processing has resulted in orders from two West Coast packers for similar stations.

In starch, several domestic and overseas producers will employ D-O centrifugals of virtually every design for current modernization and process modification projects. Our Dutch subsidiary has put into operation three corn and potato starch washing and processing plants in Germany and Finland.

NON-METALLICS—A new clay and sand plant in Idaho will utilize considerable D-O sedimentation, filtration and centrifugal classification equipment and a Pennsylvania limestone producer has purchased Classifiers and a large Thickener for installation in an earthen basin. Also in the clay industry, the longest Oliver drum filters ever fabricated—24 feet in length—will be shipped early next year to a Southern producer.

We have noticed with much concern the apparent growing tendency of many users of services and equipment to buy almost exclusively on price rather than on demonstrated product quality and the essential engineering services made available to them during planning and after installation. This is not a new subject—and one on which there has been much forceful editorial comment in the technical press.

This practice confronts the supplier with the practical short range choice of sacrificing product quality and needed engineering, losing the business, or taking it at a loss. For our own part, we do not propose to fall into this trap which, economic considerations aside, can only result in arresting technological advance and which could have a profound effect on the leadership of the free world in things technical.

J. D. HITCH, JR.
Chairman of the Board

December 1, 1959

Chemicals—an international dish

IF THERE'S ONE TREND which typifies the daily flow of mail across the editorial desks of CEP these days it's the heavy volume of announcements devoted to chemical operations abroad. New overseas plants, overseas plant expansions, and new overseas companies are the modus operandi of the chemical industry today. And if Horace Greeley were addressing our young industry today, he'd tell it to go Western for sure, but he'd expand and say go to Western Europe. Then keep on going and go to Japan and don't overlook our neighbors, in Latin America, for if there's one thing sure about the decade ahead it's that the BIG growth in chemicals is coming from abroad.

Who's Who

The domestic companies have been far from sleeping at the switch, it's for sure, and a quick rundown of some recent newsmakers reads like a blue book of the industry: Dow Badische, U.S.I.-International, National Carbon Co. (India) Ltd., L'Air Liquide, Kali-Chemie-Stauffer, Japan Upjohn, Ltd., Esso Export Corp., Reichhold Chemie, Monsanto Chemicals (Australia), DuPont, S.A. de C.V. Cia Mexicano de Explosives, Shell-St. Gobain-Texas Butadiene-Cabot, and the list can go on and on. In fact, the Manufacturing Chemists Assn. reports nearly 50 per cent of its members are involved in foreign operations.

Talk to these companies individually and collectively and you find them moving into the foreign operations for both the practical expedient of increasing business and the vital necessity of keeping the business they already have overseas. For while world consumption outside the U. S. has been increasing at a fabulous percentage rate, the new production facilities coming onstream in many countries are rapidly closing the door on imports into these areas. Polyethylene's a good case in point. U. S. exports of this well-known polymer stood at roughly 250 million lbs. in 1958. This is expected to plummet to about half within five years while the foreign consumption pattern continues sharply upward. The net losers: the companies who have failed to get into the swim. This same pattern will develop with practically every major chemical product, for as demand grows, new plants will continue to come onstream—abroad.

Crumbling roadblocks

There continue to be many obstacles to operating overseas, but fortunately for the chemical companies many of these are falling by the wayside. The six-nation European Common Market (France, West Germany, Italy, Belgium, the Netherlands and Luxembourg) and the seven-nation European Free Trade Assn. (Great Britain, Norway, Sweden, Denmark, Switzerland, Austria and Portugal) were set up to foster trade among the respective member countries with a minimum of red tape and tariffs. A third group is being set up to bridge the economic and political division between the Sixes and Sevens to prevent the development of two large trade blocs. Finally, the United States is participating in this latter group which should help prevent the development of a combined bloc which could possibly function to exclude the U.S. from Western Europe markets.

What this means to the chemical marketer is that eventually he can sell his products freely among the most important consumer countries in the world unhampered by artificial tariff barriers and currency problems. The chemical producer, assured of the high potential represented by the combined markets can size his plant for large-scale operations, taking full advantage of the economies inherent in mass production.

The bright glow cast by the resurging chemical industry in Western Europe carries over to other areas of the world where some obstacles, unfortunately remain quite rigid. This is most notable in countries where nationalistic fervor overrides good economic sense and companies cannot freely enter into the economic stream. Even in most of these, however, partnerships can be made with government agencies which, while frustrating, are workable and profitable.

opinion and comment

Sell engineering

Engineering has a public relations job to do and, happily, we believe that it is doing it—or at least part of it. The present ideological battle between nations has, thanks to a great deal of common sense on both sides, kept out of the shooting stage, that is out of the massive shooting stage, and it has come down to, and continues to be, an economic battle between the two ways of thinking. Now economic battles are the joy of engineers. Engineers are never concerned with anything else during their industrial lives. Management and administration, even though made up largely of first class engineers, is still completely dependent upon other engineers for the necessary process, production, maintenance and market decisions to enable the chemical corporation to win its everyday economic battle. Over the long run American engineers must be able to produce better, produce cheaper, produce faster, and exploit more widely the marvels of science. However, today we believe that the pendulum of public opinion is swinging too far toward science. The educational machine is tilted too far in one direction, and the pendulum stays too briefly in the engineering arc. Succinctly, the scientist's purpose is to explore ideas, to explore frontiers; the engineer's, to make these discoveries economical enough to be used by the great mass of people. To correct this swing of the pendulum, engineers must tell the public more about themselves and their work. Engineers Joint Council, of which A.I.Ch.E. is a member, made a start in this direction last year when it took advertisements in magazines for editors, writers, and publishers to show that engineers are essential to today's civilization. Engineers must, too, tell the students in the high schools about engineering, and to this end the Local Sections of the A.I.Ch.E. are doing a good job in supplying career guidance information for young people. As a matter of fact, a Purdue opinion poll taken about a year and a half ago proved quite handily that the young people of today have a pretty clearcut conception of engineering. This has not, however, prevented many of the good students from being drawn into science curricula instead of engineering curricula. Engineering must continue to do a guidance job, a public relations job, to guarantee 1) that the public knows what engineers are doing and how important they are economically; 2) that the Government knows how vital engineering is in this present battle of titans; 3) that the students who will make good, happy engineers are kept out of educational courses that will lead them into being unhappy scientists.

Engineers are aware of their public relations responsibilities: they know that they must influence, they know that they must tell their story. In addition to the professional societies and trade associations, which have a responsibility in this area, the industry of the United States and the Government, too, must see that the pendulum does not swing too far in one direction to the detriment of the delicate balance necessary for the full utilization of all professions.

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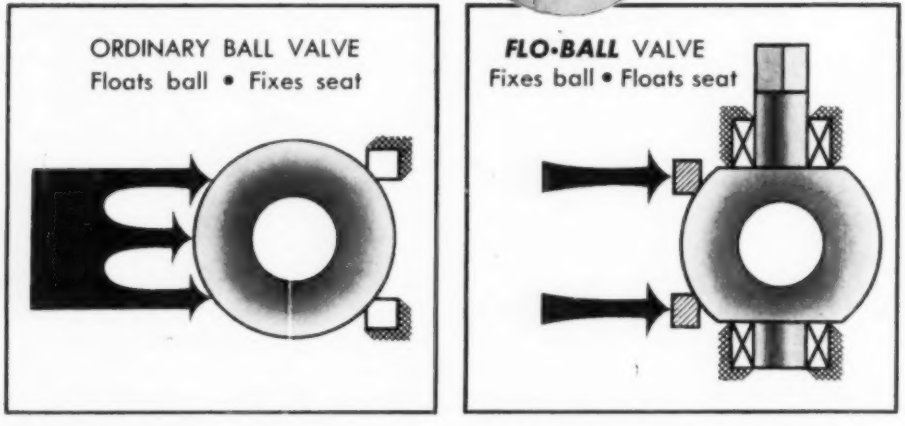

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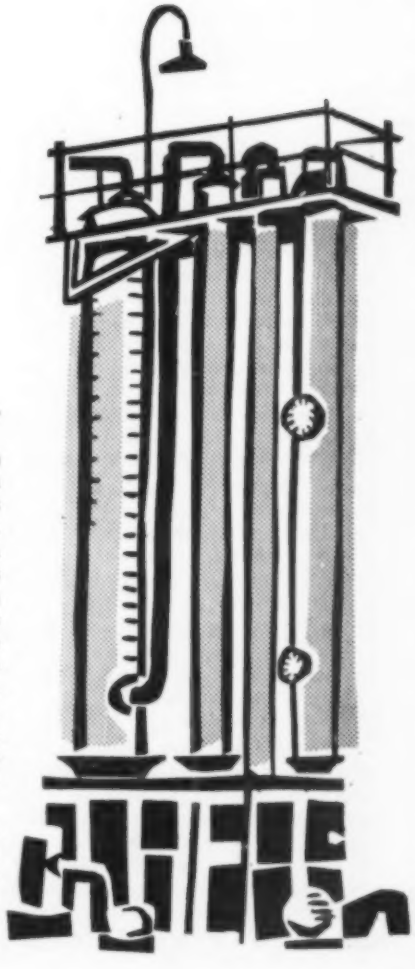
Societe Belge de L'Azote et des Produits Chimiques du Marly

Acetylene/ethylene from naphtha

Here's a fully developed method for producing these olefins from naphtha. Flexible process makes it possible to produce ethylene and acetylene over a wide range of product ratios.



The S.B.A.-Kellogg Process produces acetylene and ethylene in a wide range of product ratios by means of pyrolysis. Combined yields of acetylene and ethylene are 52 to 70 per cent by weight of pyrolyzed naphtha. This is the portion of the total naphtha feed which is actually cracked as distinguished from the portion of naphtha which is converted to synthesis gas. The portions of naphtha pyrolyzed and converted to synthesis gas can be varied. The flexibility of performance is achieved by specially designed burners. Their operational ability has been demonstrated in semi-commercial tests over a period of years with ever-increasing production capacity. The most recently developed burner has a capacity conservatively rated at ten and a half million pounds per year of acetylene plus ethylene. Its performance is remarkable because of its freedom from carbon deposition, its stability, and reliability in operation.

Acetylene product of a purity in excess of 99 per cent is extracted in a novel recovery process which uses inexpensive, readily available solvents. The use of anhydrous ammonia as a selective solvent for acetylene allows low temperatures to be employed in the acetylene separation. This avoids polymer formation and permits the use of hot quench water from the burner as a heating medium. Operation has been demonstrated in a semi-commercial unit processing pyrolysis gas sufficient to produce two million pounds per year of acetylene plus ethylene.

Production of acetylene from hydrocarbons has occupied the attention of researchers for many years. A number of basic process techniques have been previously reported. These include (1) Schoch Electric Arc, (2)

Sachsse Partial Oxidation, (3) Wulff Regenerative Furnace Cracking, (4) Tennessee Eastman Process. This paper presents data for the SBA-Kellogg Process—a fully developed method for production of acetylene and ethylene from naphtha, which is ready for commercial use.

The burner

In 1928 the well-known Belgian chemical company Societe Belge de L'Azote et des Produits Chimiques du Marly, began research to develop a commercially-practical process for making acetylene from a wide range of hydrocarbons. Two distinctly different types of burners have been perfected for use with hydrocarbon feeds of varying molecular weight. The first, a burner for natural gas, will be referred to as Type I, while the second, a burner for liquid hydrocarbons, will be referred to as Type II. A special feature in the design of both burners is a water curtain which keeps the inner walls free from carbon build-up. Another feature is the ability to convert from Type I to Type II operation in a matter of minutes. This paper is concerned primarily with the Type II burner and its application to naphtha for production of acetylene and ethylene, including a brief discussion of the process steps for recovery of high purity acetylene product.

Type I burner is illustrated in Figure 1. It operates on the principle of partial combustion of light hydrocarbons with oxygen to produce acetylene as a main product. Only minor amounts of ethylene and other hydrocarbons are produced. The unique design of the burner block and special mixing device contribute to flame stability and minimize the tendency for backfiring. No refractory is used, the internal water-cooled metal surface being made of stainless steel. The burner is kept free of carbon build-up by a flowing curtain of water along the inner wall of the combustion chamber, thereby avoiding the use of mechanical cleaning devices or an oxygen lance.

Type II burner (Figure 2) was developed for operation on hydrocarbons with molecular weights in the range of propane through heavy naphtha. High temperature cracking is achieved by injecting the hydrocarbon in a vapor phase into a preformed high temperature flame. After a short but adjustable reaction time, there is an instantaneous water quench. Any gaseous fuel or the residual gas, after acetylene and ethylene extraction, can be burned with oxygen to provide the high temperature flame. The flame is completely stable and reliable. A protective blanket of sweep steam flows into the top of the combustion zone along the wall. Additional steam may be added to adjust the flame temperature to any desired level. In this burner a portion of the naphtha can be burned to provide part of the heat needed for cracking or to supply additional synthesis gas in instances when it is advantageous. As can be seen in Figure 2, oxygen and fuel are

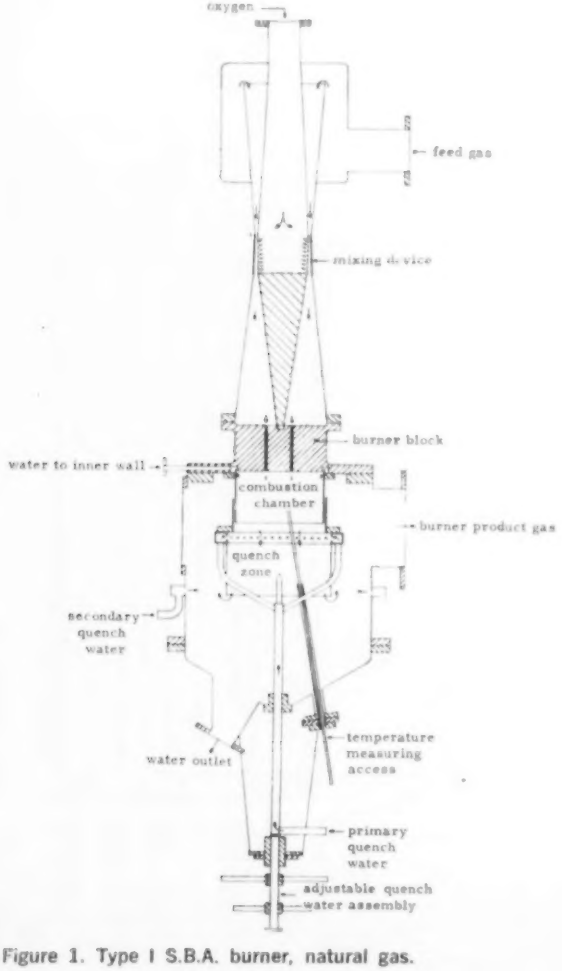


Figure 1. Type I S.B.A. burner, natural gas.

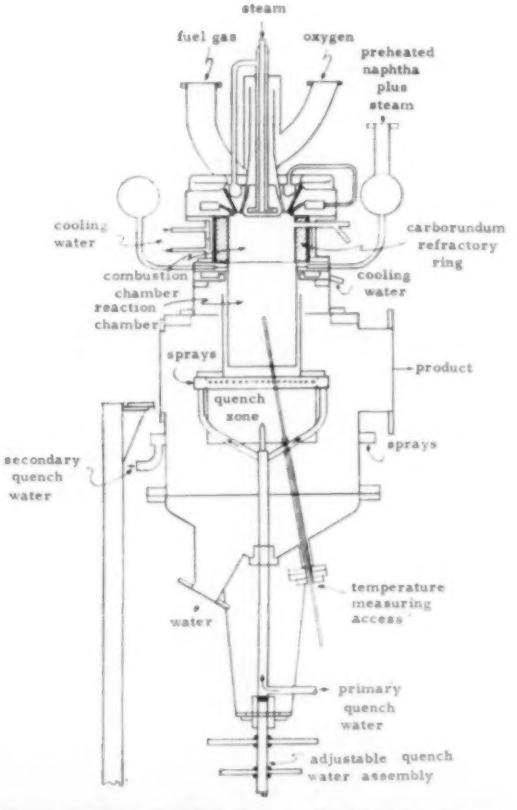


Figure 2. Type II S.B.A. burner, liquid hydrocarbons.

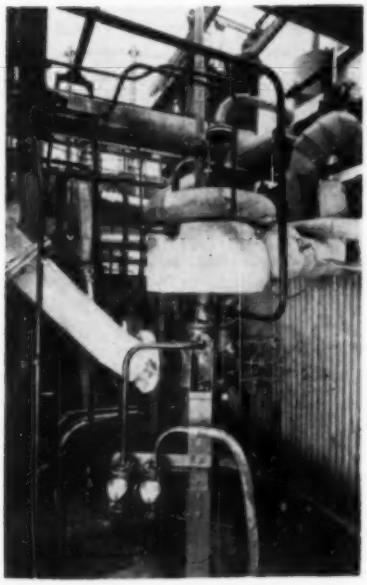


Figure 3. A Type II S.B.A. burner installed and operating.

fed to the top of the burner in separate streams. Either or both of the streams may be preheated depending on a balance of process economics versus the addition of process complexity. The flame is formed by oxygen and gas passing downward through separate multiple ports arranged in a circle around the top of the combustion chamber.

Stainless steel is used for all internal metal surfaces. All other metal parts are carbon steel. The only refractory used is a small, easily replaceable ring section of carborundum which fits into the top portion of the burner to form the combustion chamber.

The hydrocarbon feed to be pyrolyzed is mixed with steam and vaporized in a preheater. It is then sent through the burner manifold to a multiport ring which evenly distributes the stream at high velocity into the reaction chamber. A flowing curtain of water on the wall of the reaction zone keeps it free of carbon deposits. At the end of the reaction zone quench water for instantaneous cooling is injected in a spray uniformly covering the whole cross-section area. The length of the reaction zone can be varied by adjusting the quench position. Gas and quench water are disengaged at the bottom of the burner, the out-going water carrying with it about one third of the small amount of carbon and tar formed in the process. After clarification treatment the same quench water can be recycled to the burner. A photograph of the current commercial size Type II burner having a capacity of ten and a half million pounds per year of acetylene plus ethylene appears in Figure 3. Based on experience in scaling up to this size from the operation of a number of burners of smaller size, it is anticipated that larger burners can be built to operate successfully at substantially higher capacities.

Table 1. Typical naphtha analyses and inspections

Description	Kuwait Light Naphtha			Heptane Cut
Density at 68°F	.700	.701	.703	.729
IBP, °F	89.6	95	99.5	181.2
5	114.8	123.8	132.8	210.3
10	120.2	138.2	143.0	202.1
20	131	157	160.7	202.1
30	140.9	174.2	175.1	203.0
40	150.8	186.8	190.4	203.0
50	160.7	201.2	204.8	204.8
60	168.8	215.6	220.1	205.8
70	179.6	231.8	234.5	205.8
80	191.3	246.2	251.6	205.8
90	205.7	264.2	272.3	207
95	212	276.8	290.3	207
E.P.	266	289.4	305.6	207
Carbon, Wt. %	84.8		85.2	84.9
Hydrogen, Wt. %	15.2		14.8	15.2
Sulfur, Wt. %	0.03		0.04	0.002
Naphthenes, %	10.6	10.8	5.1	37.9
Aromatics, %	6.8	8.4	4.2	6.3

Burner tests

Naphtha pyrolysis tests reported here were run intermittently in a Type II burner over a ten-month period. These tests, each lasting 2-6 hours, were run primarily to develop correlations which would permit accurate prediction of the complete product distribution and the operating conditions for any desired production ratio of ethylene to acetylene. Several demonstration runs of 2-3 weeks' duration were also made.

Data were obtained using several light naphtha feeds at steam-to-oxygen ratios varying from 0.2 to 2.0 and at oxygen-to-naphtha ratios from 0.6 to 1.2 weight. Some typical naphtha inspections are shown in Table 1. The oxygen used in all runs had a purity of about 92 per cent. Coke oven gas, hydrogen and recycled product from the burner were used as fuel gas. Typical analyses are given in Table 2. Contact time was varied by changing both the length and diameter of the cracking zone. The effect of varying the dimensions of the combustion zone was also investigated.

Oxygen and fuel gas were measured with calibrated flowmeters and then fed to the head of the burner without preheating. Naphtha was pumped from a feed tank, measured, vaporized, and superheated to about 600°C and injected at the top of the cracking zone. Steam was normally added at one or more points in the combustion and cracking chambers. The individual steam flows were metered and superheated separately prior to injection. After quenching, the product gas was water-scrubbed, metered, and then generally sent to the flare. In the 2-3 week demonstration runs complete purification processing was carried out on the pyrolysis product gas.

Gas analyses were made by means of mass spectrometry but gas chromatography, infra-red spectrometry, and Orsat methods were used for control purposes.

Combustion reactions. The minimum steam requirement for the process is set by the requirement for cooling the walls of the combustion chamber and by the amount of steam which must be fed with the naphtha to avoid coking in the preheater. Additional steam may be added to modify combustion reactions. Material balance data presented in Table 3 show that high steam rate influences product composition in two fundamental ways.

1) The flame temperature is reduced owing to the heat capacity of the steam. The lower temperature results in more complete combustion to CO_2 and H_2O.
2) Steam enters into the combustion zone reactions. It shifts, by mass action effect on the equilibrium balance, the relative proportions of CO, CO_2 and H_2 in the product gases.

The optimum quantity of steam will be a function of the relative values placed on steam, naphtha, combustion gas, and the H_2 and CO in the residue gas. Where the residue gas is in excess of the requirement for combustion and/or use as a synthesis gas, the addition of more steam to the

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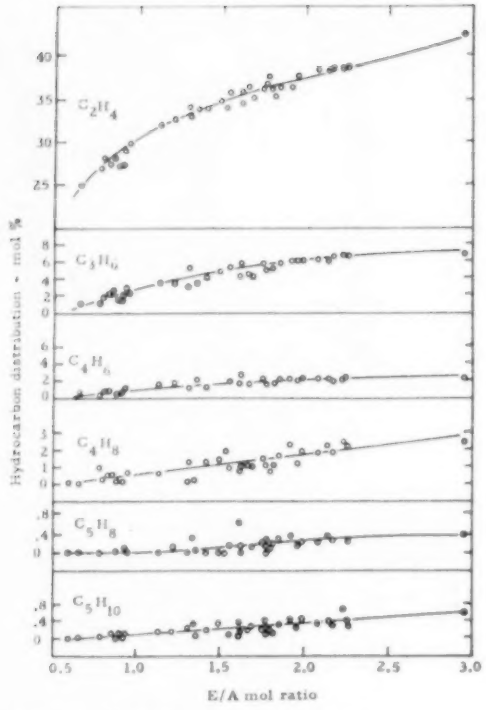

Figure 4. Pyrolysis product distribution.

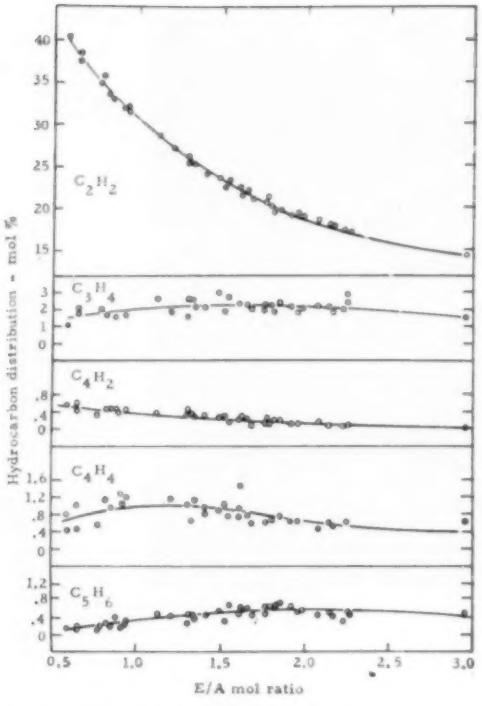

Figure 5. Pyrolysis product distribution.

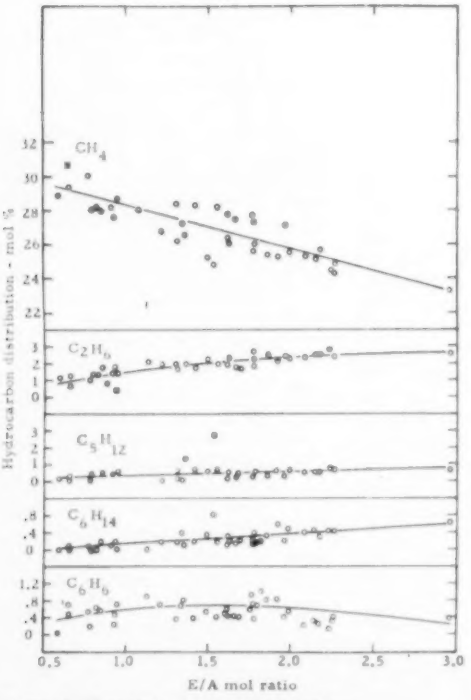

Figure 6. Pyrolysis product distribution.

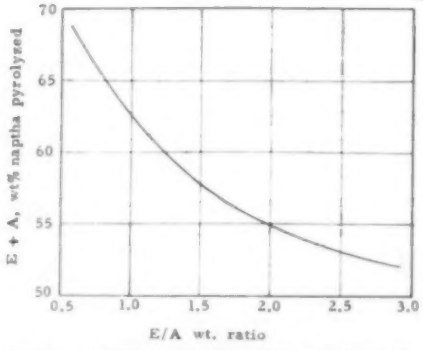

Figure 7. Yield of ethylene plus acetylene as a function of the ratio ethylene to acetylene.

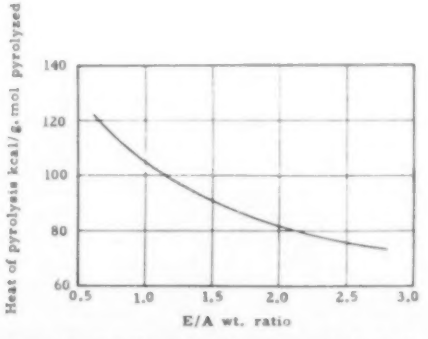

Figure 8. Relationship between pyrolysis heat duty and ethylene-acetylene ratio.

burner is an attractive way to reduce the quantity of residue gas. At the same time higher yields of acetylene and ethylene are obtained and higher concentrations, after CO_2 removal from the pyrolysis product gas, lead to greater economy in product recovery. When synthesis gas is desired in a larger proportion to acetylene and ethylene, the steam addition is cut accordingly. As the last column in Table 3 shows, the fraction of naphtha converted to carbon oxides can also be somewhat reduced by maintaining a high fuel to oxygen ratio in the combustion zone.

A considerable degree of control can be exerted over the temperature profile inside the burner and over the relative proportions of combustion products in the burner effluent. Equilibrium flame calculations serve to indicate directionally the effect of combustion zone variables but further adjustments are required in order to make accurate predictions. A detailed consideration of this is not within the scope of this paper but is to be reported in another paper at a future date.

Product distribution. The product gas rates for each run were adjusted to 100 per cent carbon balance, the adjustment generally being less than 5 per cent. Water make was calculated from oxygen balance and an overall heat balance was run to determine outlet temperature prior to quench. Hydrogen balance was used as a check. When it was outside the range of 97-102 per cent the run was discarded. The fraction of naphtha carbon converted to $CO+CO_2$ (referred to as $N_c \rightarrow CO + CO_2$) was calculated and the remainder used to define the percent of naphtha pyrolyzed. The distribution of hydrocarbon products was determined directly from the product gas analysis.

The approach used was to consider the pyrolysis reactions as being separate from the combustion process and dependent on the latter only for the supply of heat. This was found to give quite satisfactory correlations. In confirmation of past observations, the distribution of pyrolysis products was found to be primarily a function of outlet temperature.

When the exact composition of pyrolysis products is known, the heat of pyrolysis can be determined. An overall heat balance will then reveal the fuel and oxygen requirements for any possible combination of preheat temperature, steam rate, oxygen purity, and fuel gas composition.

The results of the pyrolysis tests are presented in the form of correlations of hydrocarbon product distribution for a light naphtha of 35 to 150°C (95 to 302°F) boiling range from Kuwait crude (see Table 1 for inspections). These correlations, with minor variations, are typical of those which have been developed for other naphthas and other operating conditions. For convenience the ethylene/acetylene product ratio has been used as a factor for measuring severity of operation. As will be shown, this ratio decreases with an increase in severity of the operating conditions. The distribution of hydrocarbon pyrolysis products over the range of 0.5 to 3.0 ethylene/acetylene ratio is shown in Figure 4 for olefins, Figure 5 for acetylene, and Figure 6 for paraffins and benzene.

As the ethylene/acetylene ratio increases (decrease in severity):

Table 2. Typical fuel gas analyses.

Source	Recycle Product (After CO_2 Scrubbing)	Coke Oven Gas	Hydrogen
Analysis and Mol %			
H_2	34.5	59.9	99.66
N_2	1.5	3.0	0.34
A	1.4		
O_2	0.0	0.7	
CO	36.6	5.9	
CO_2	0.9	1.5	
CH_4	7.4	25.9	
C_2H_2	7.8	0.1	
C_2H_4	7.5	2.0	
C_2H_6	0.27		
C_3H_4	0.73		
C_3H_6	0.60		
C_4H_2	0.11		
C_4H_4	0.17		
C_4H_6	0.19		
C_4H_8	0.06		
C_5H_6	0.06		
C_5H_8	0.01		
C_5H_{10}	0.00		
C_6H_{12}	0.04		
C_6H_6	0.16		
C_6H_{14}	0.00		
H_2S		0.2	
Carbon Index	0.840	0.375	0.00

Table 3. Materials balance data showing effect of steam addition.

Ethylene/Acetylene Mol Ratio	0.50	1.68	0.44	1.69	1.94
Feed Rates					
Naphtha Kg./Hr.	374	510	230	373	360
Fuel Gas Nm^3/Hr.	272	250	199	203	245
Oxygen Nm^3/Hr.	250	232	187	178	188
Steam in Combustion Zone Nm^3/Hr.	60	60	462	542	545
Steam in Naphtha Nm^3/Hr.	270	112	185	133	127
Fuel Gas Source		Coke Oven Gas			
Carbon Index (Atom C/Mol)	.387	.400	.392	.390	.392
Naphtha Preheat, °C.	600	500	580	580	580
Calculated Flame Temp., °C.	2680	2630	2030	1880	1380
Product Gas Rate Nm^3/Hr.	962	979	584	640	650
Product Gas Analysis					
H_2	43.7	35.4	42.5	32.5	33.3
N_2	2.8	1.8	4.3	3.3	3.6
CO	25.1	24.1	17.8	12.3	10.9
CO_2	5.3	4.8	10.5	10.0	9.5
CH_4	8.0	10.4	8.9	13.5	14.0
C_2H_2	9.3	7.1	10.0	8.5	7.7
C_2H_4	4.6	11.9	4.4	14.4	14.9
Higher Olefins	0.3	2.5	0.5	2.8	3.1
Higher Acetylenes	0.6	1.1	0.7	1.6	1.8
Higher Paraffins	0.1	0.8	0.2	0.7	0.4
Aromatics	0.2	0.1	0.2	0.4	0.2
Yield Basis Naphtha Pyrolyzed, Wt. %					
C_2H_2	41.0	20.4	39.8	19.5	17.3
C_2H_4	22.0	37.0	19.0	35.8	35.8
C + Tar	2.5	0.5	3.0	1.3	0.8
$N_C \rightarrow CO + CO_2$	31.7	22.6	24.0	11.6	6.2
Yield Basis Total Naphtha Feed, Wt. %					
C_2H_2	28.0	15.8	30.3	17.3	16.2
C_2H_4	15.0	28.6	14.4	31.6	33.6
Total	43.0	44.4	44.7	48.9	49.8

1) Higher olefin and diolefin increase along with ethylene (Figure 4).
2) Acetylene and diacetylene decrease together, but methyl acetylene, vinyl acetylene, C_5H_6 (probably cyclopentadiene) (Figure 5) and benzene (Figure 6) go through a maximum at a ratio of 1.5 to 2.0.
3) Methane concentration decreases but higher paraffins increase (Figure 6).

In addition there is a continuous production of tar (a high molecular weight condensable liquid) and carbon which must be removed from the water and gas effluent. Present data indicate a carbon plus tar fraction yield totaling about 0.5 per cent by weight on naphtha pyrolyzed. The ratio of carbon to tar increases as the operating severity is increased (the ratio ethylene to acetylene is decreased).

Examination of the pyrolysis product distribution shows that as ethylene concentration increases, there is a substantial rise in the percentage of hydrocarbon by-products. This is particularly evident on a weight basis. Figure 7 (which was derived from Figures 4, 5, and 6) relates the weight yield of acetylene plus ethylene from pyrolyzed naphtha to the ethylene/acetylene weight ratio. The sharp drop-off in yield due to by-product formation is apparent. Experiments have been made which demonstrate that certain by-product hydrocarbons may be recycled and cracked to produce high yields of acetylene and ethylene. Table 4, based on micro-burner tests, shows that butadiene is converted to acetylene and ethylene in the same proportion as the base feed "propagas" (a mixture of C_3H_8 and C_4H_{10}).

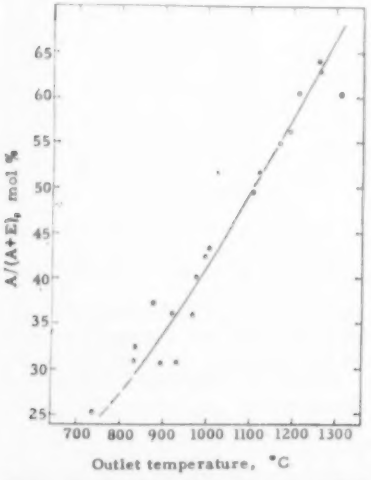

Figure 9. Relationship between outlet temperature and acetylene plus ethylene product formation.

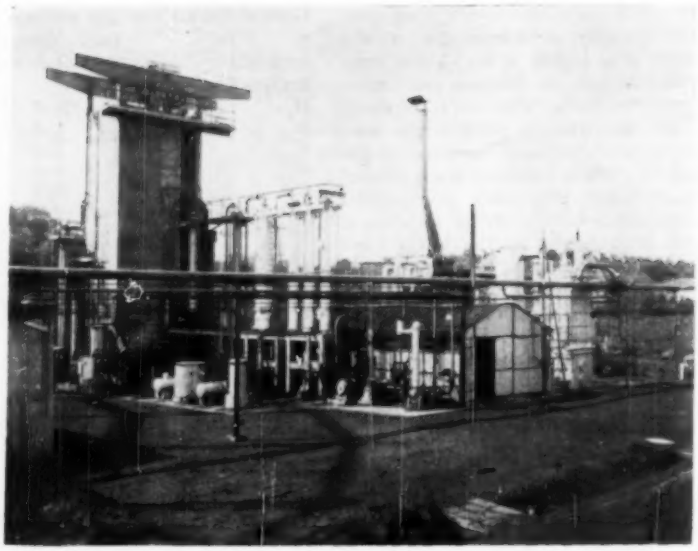

Figure 10. The Societe Belge de l'Azote pilot plant at Marly, Belgium.

Heat duty. The relationship between pyrolysis heat duty and the ethylene/acetylene ratio as shown in Figure 8 has been calculated from the product distribution shown in Figures 4, 5, and 6 using API Project 44 (5) values for heats of formation. As the ratio is raised there is a reduction in the endothermic heat of cracking. At the same time the required outlet temperature is lowered markedly. Figure 9 shows a nearly linear relationship between the percent acetylene in the combined acetylene plus ethylene product and the outlet temperature established by heat balance. Within the range stated previously, changes in other variables did not affect this relationship. Since the naphtha preheat temperature is set, it is apparent that the correlations in Figures 8 and 9 fix the heat duty to be supplied by combustion. As ethylene/acetylene ratio is increased there is a marked reduction in fuel requirement.

Effect of other variables

In order to gain additional insight into the characteristics of different combustion reactions, fuel gases of different compositions were employed in the burner tests. Table 5 shows the results obtained with three different fuel gas compositions arranged in order of decreasing carbon number.

In addition to Kuwait light naphtha, data were obtained on a narrow boiling C_7 cut (see Table 1 for inspection) and typical results are given in Table 6.

High purity. The overall problem of recovering high-purity acetylene from the burner effluent gases is solved by the following process steps:
1) Carbon removal,
2) Carbon dioxide removal,
3) Removal of higher acetylenes and other hydrocarbons of high molecular weight,

Table 4. Cracking of butadiene in presence of propagas micro-burner tests.

Ethylene/Acetylene Mol Ratio	1.06	1.08	1.07	1.05
Feed Rates				
Propages, gm/Hr.	1905	1742	1714	1905
Butadiene, gm/Hr.	0	166	189	0
Fuel Gas, Normal m^3/Hr.	1.075	1.075	1.075	1.075
Oxygen, Normal m^3/Hr.	1.015	1.015	1.015	1.015
Total Carbon in C_3–C_4 Feed, Atoms C/Hr.	132.24	133.20	132.94	132.24
Carbon In Butadiene Feed, Atoms C/Hr.	0	12.26	13.99	0
Carbon In Butadiene Out, Atoms C/Hr.	0.864	1.896	2.032	0.724
Butadiene Conversion–%	0	91.6	91.7	0
Carbon Yield Basis Total Atoms C in C_3–C_4 Feed				
C_2H_2, %	18.6	19.0	18.8	18.8
C_2H_4, %	19.6	20.0	20.1	19.7

4) Separation of acetylene from ethylene and lighter components,

5) Pure acetylene recovery from the solvent.

The SBA and Kellogg organizations collaborated in studying problems related to all these steps in order to develop efficient and commercially-practical solutions. Data developed were used by M. W. Kellogg for the design of a complete commercial plant. The process steps were worked out and tested in the semi-commercial size pilot unit located near Brussels, Belgium. This installation includes facilities for testing the acetylene product quality by processing it to vinyl chloride. The pilot plant is pictured in Figure 10.

In the schematic flow diagram (Figure 11), the fuel gas, oxygen, and steam are introduced to the burner without preheating. The hydrocarbon feedstock to be cracked is mixed with steam then preheated to a temperature corresponding to incipient cracking. Burner product gas is quenched with water. The quench water removes about one third of carbon and heavy oil formed in pyrolysis.

The quenched gases from the burner are processed to remove carbon particles which were not previously taken out and carried away by the quench water. For cleaning, the gases are passed through special water scrubbing equipment and then washed by oil. It has been demonstrated that electrostatic precipitation also provides an effective means for final cleanup of the gas.

Quench water and effluent from the water scrubbing are treated in a clarifier with flocculating agents. Carbon settles to the bottom of the clarifier and is withdrawn as sludge; oil is skimmed off the top of the clarifier. Clear water is withdrawn and recycled.

It is desirable to remove carbon dioxide at an early stage in the operation. After compressing the burner gases to a moderate pressure in the order of 150 psig, the bulk of carbon dioxide removal is accomplished by means of an absorption system which uses an ammoniated ammonium carbonate solution. Caustic scrubbing completes the cleanup.

Steps 3 and 4 in the process scheme determine the quality of the extracted acetylene product. Recovery of acetylene requires separation from heavier and lighter components. The heavy components include: the higher acetylenes (methyl acetylene, diacetylene, vinyl acetylene), propadiene, propylene, and butadiene. It is desirable to remove these components at an early stage in the process—particularly the higher acetylenes and butadiene which have a propensity to polymerize. The separation of these heavy ends should be accomplished in a way which both avoids polymerization and the handling hazards inherent in disposal of higher acetylenes. A solvent for this purpose should be such that acetylene exhibits a high volatility relative to the heavy components and it should be readily available and inexpensive. Heavy naphtha meets all these requirements and accomplishes efficient separation.

The heavy naphtha is used in what might be called a prepurification step, in which the heavy impurities are eliminated to such a degree that the residual concentrations are readily separated from acetylene in the final purification. Better than 94% of the methyl acetylene and almost all of the higher acetylenes and heavier hydrocarbons are removed by the prepurification step. Product losses are negligible, amounting to less than 1% for both ethylene and acetylene.

In the absorption and stripping operations conducted in the pilot plant, no polymer formation or equipment fouling was observed. The low temperature level (which does not exceed 200°F at any point) is considered to be responsible. After a long period of time, traces of heavy ends may build-up in the naphtha solvent.

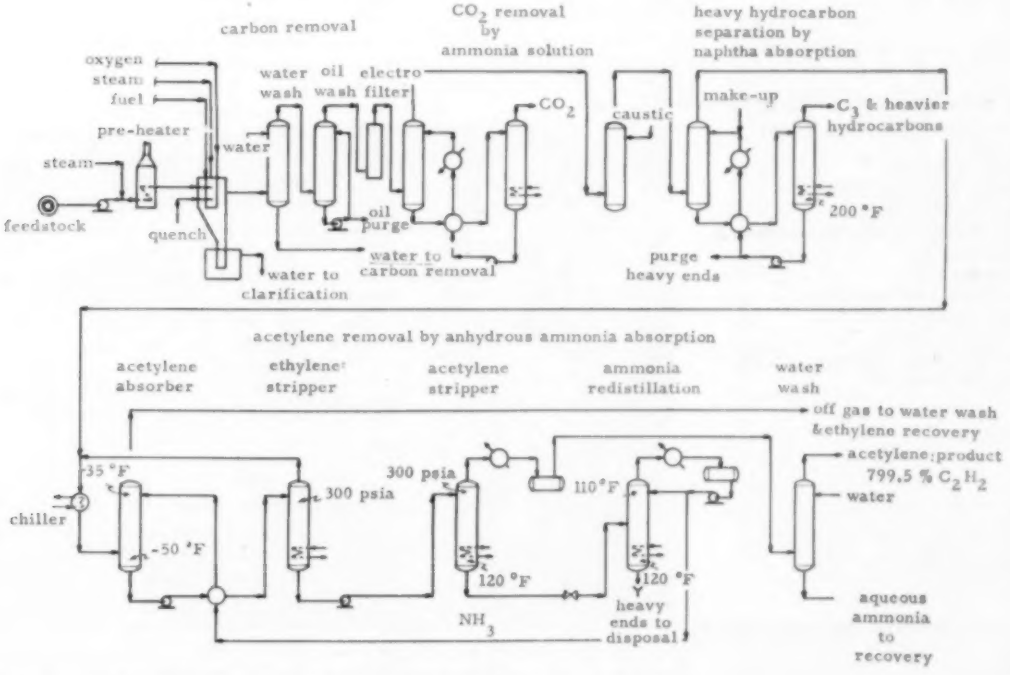

Figure 11. S.B.A.-Kellogg process for acetylene and ethylene from naphtha.

This build-up can be easily controlled by provision for a continuous purge stream and make-up of lean oil—a safe means for disposing of the heavy end to fuel.

After the heavy hydrocarbons are removed, an extractive operation employing a solvent with a high selectivity for acetylene is required. Anhydrous ammonia is highly selective for acetylene, low in cost, readily available. In the addition it serves as a safe medium for transferring acetylene under pressure either in solution or in vapor-phase mixturess.

Acetylene is preferentially absorbed by anhydrous ammonia over hydrogen, carbon monoxide, methane, and ethylene. The operation is conducted at low temperature levels on the order of –35 to –50°F and at any pressure level from atmospheric up to about 150 psia according to the intended use of the residue gas. Although ammonia is selective for acetylene, a slight amount of ethylene is also taken up by the rich ammonia solvent. This ethylene is separated in the ethylene stripper and is recycled to the acetylene absorber. Ammonia-containing acetylene from the bottom of the ethylene stripper is pumped to the acetylene stripper where acetylene mixed with ammonia vapor is taken off overhead. Ammonia dilution of the acetylene permits stripping to be accomplished safely at a pressure in the order of 300 psig, and permits the overhead to be transferred to the point of acetylene use at much higher pressures than would be permissible if pure acetylene were transported. Although it is not within the scope of this paper, it may be stated that extensive tests have been conducted in a 4-inch tube, 100 feet long, to establish the safe concentration limits for ammonia-acetylene mixtures. When the ammonia-acetylene mixture arrives at the point of acetylene use, it is immediately reduced to the safe pressure level for pure acetylene. The ammonia is removed by water washing, and then recovered for redistillation.

Small traces of heavy ends are retained in the ammonia solvent when it leaves the bottom of the acetylene stripper. These are separated from the ammonia by distillation. The impurities are removed as a bottoms cut.

Since the anhydrous ammonia solvent used in the SBA-Kellogg process has such a low boiling point, use of this solvent provides a twofold advantage: The low temperature level of absorption and stripping avoids polymer formation and fouling of equipment, and the low level heat required for stripping and ammonia redistillation (at 120°F) can be recovered from the burner effluent quench water.

In the separation process an acetylene product purity of better than 99.5% is obtained. The major impurity remaining is methyl acetylene. Further treatment may achieve an even higher purity. When pre-purification is used a normal purity of 99.8% is obtained. #

Table 5. Materials balance data for Kuwait L.N. feeds.

Ethylene/Acetylene Mol Ratio	0.77	0.82	0.93*	0.88
Feed Rates				
Naphtha, Kg/Hr.	350	350	350	350
Fuel Gas, Normal m^3/Hr.	234	250	210	376
Oxygen, Normal m^3/Hr.	233	232	193	203
Steam, Normal m^3/Hr. To Combustion Zone	47	52	50	46
With Naphtha	190	200	200	191
Fuel Gas Source	Recycle Gas	Coke Oven Gas	Coke Oven Gas	Hydrogen
Carbon Index (Atoms C/mol.)	0.840	0.375	0.390	0.00
Naphtha Preheat, °C.	510	420	600	500
Cal. Outlet Temp., °C.	1195	1190	1120	1139
Product Gas, Rate, Normal m^3/Hr.	910	834	770	793
Product Gas Analysis				
H_2	32.9	38.4	40.3	50.0
N_2	3.2	2.9	3.0	2.3
CO	34.0	30.2	23.2	17.6
CO_2	7.4	6.7	5.2	2.8
CH_4	6.8	6.2	8.7	9.4
C_2H_2	7.9	7.3	8.7	8.5
C_2H_4	6.1	6.0	8.0	7.5
Higher Olefins	0.6	1.0	1.3	0.6
Higher Acetylenes	0.8	0.8	0.9	0.9
Higher Paraffins	0.3	0.4	0.4	0.2
C_6H_6	0.1	0.1	0.3	0.3
Yields Basis Naphtha Pyrolyzed, Wt. %				
C_2H_2	35.3	30.8	29.8	31.3
C_2H_4	29.4	27.3	30.0	29.5
Carbon Plus Tar	0.3	1.8	1.7	0.6

* *Correlated average of a series of runs.*

Table 6. Materials balance data when feeding C_7 cut.

Ethylene/Acetylene Mol Ratio	0.86	0.56
Feed Rates		
Naphtha, Liters/Hr.	350	280
Fuel Gas, Normal m^3/Hr.	245	251
Oxygen, Normal m^3/Hr.	237	230
Steam, Normal m^3/Hr. To combustion zone	75	52
With naphtha	—	200
Fuel Gas Source	Coke Oven Gas	
Carbon Index (Atoms C/mol.)	0.400	0.368
Naphtha Preheat, °C.	420	560
Calc. Outlet Temp., °C.	1065	1256
Product Gas Rate, Normal m^3/Hr.	822	771
Product Gas Analysis		
H_2	39.2	42.8
N_2	3.2	3.3
CO	26.7	26.9
CO_2	5.7	6.8
CH_4	6.5	5.6
C_2H_2	8.0	8.2
C_2H_4	6.9	4.6
Higher Olefins	2.0	0.6
Higher Acetylenes	1.1	0.8
Higher Paraffins	0.6	0.3
C_6H_6	0.1	0.1
Yields Basis Naphtha Pyrolyzed, Wt. %		
C_2H_2	29.6	39.6
C_2H_4	27.3	23.8
Carbon Plus Tar	0.4	1.4

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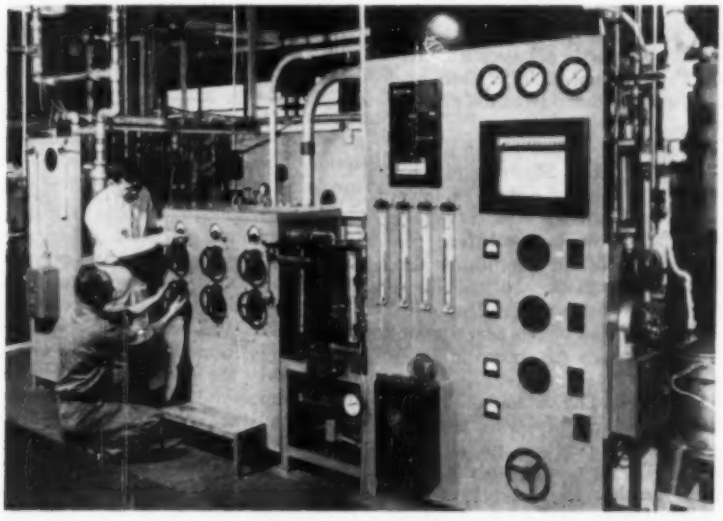
Acetylene/ethylene via thermal cracking

Here are the results of vapor-phase pyrolysis studies made by institute of gas technology with propane, butane, natural gasoline and petroleum distillates as feedstocks.

The Institute of Gas Technology has conducted research on high-temperature vapor-phase thermal cracking (pyrolysis) of hydrocarbons since 1947. Empirical correlations were developed with which product yields and compositions can be predicted from feedstock properties and reaction conditions (*11-19, 21*). A simple model of the vapor-phase pyrolysis reaction system was also developed which adequately explained the experimental results.

The major objective of this work was to obtain information on which to base the improvement of processes for conversion of liquid fossil fuels to utility fuel gases with combustion characteristics similar to natural gas. For this reason, the products of primary interest were low molecular weight paraffins. In recent studies, pyrolysis conditions were extended into a range where commercially recoverable yields of acetylene and ethylene were produced.



The pyrolysis apparatus showing the pyrolysis furnace behind the electric power panel being operated by the men. Background, far left, acetylene recovery system.

Apparatus and procedure

The apparatus (see flow diagram of Figure 1) was similar to the equipment used by Hasche (*5*). The reactor tube was constructed of silicon-nitride-bonded silicon carbide and measured 6 inches O.D. by 4 inches I.D. by 68 inches long. The ends of the reactor-tube were connected midway through the furnace walls to Type 310 stainless steel castings by compression-type ball and socket joints. Heat was supplied by six silicon carbide heating elements spaced symmetrically around the tube. Either a 3 or 3.5 inch O.D. silicon carbide corebuster (cylindrical center core) was placed inside of the reactor tube and extended the entire heated length. The reactants were forced to pass through the narrow annulus formed by the reactor tube and the corebuster.

Hydrocarbon feed and carrier steam were measured, preheated separately in electric and gas-fired heaters, and then mixed in a chamber at the inlet to the reactor tube. The hydrocarbon preheat temperature was kept low enough to prevent cracking from occurring in the heater coils. The steam was superheated to between 1700° and 2000°F.

Product gas leaving the reactor tube was rapidly quenched to about 100°F by direct contact with a water spray. The cooled product gas and quench water were removed together through a liquid-sealed vacuum pump which maintained subatmospheric pressures in the reaction space. The product gas was metered after separation from the quench water. A portion of the product gas stream was collected continuously in a water-sealed holder for mass spectrometer analysis. Temperature measurements of the preheated feeds, reactants mixture, and products at the reactor tube discharge were made with chromel-alumel thermocouples. The reactor tube wall temperature was measured with an optical pyrometer.

The feedstocks used in these experiments were propane, *n*-butane, natural gasoline (77.3°API, 5.26 C/H weight ratio) and jet engine fuel (55.7°API, 5.74 C/H weight ratio JP-4). Operating conditions included reactor tube wall temperatures from 2120° to 2690°F, reaction zone pressures from 0.231 to 0.987 atmospheres, residence times in the heated reactor annulus from 0.0175 to 0.139 seconds, and steam/hydrocarbon feed weight ratios from 2.03 to 8.03.

Data presentation. Selected operating data for each feedstock are shown in Table 1. All gas volumes were corrected to standard cubic feet (SCF) of dry gas at 60°F and 30 inches mercury pressure. Acetylene and ethylene yields are based on the volume and mass spectrometer analysis of the dry product gas recovered after the water quench. Higher acetylenes were not included in the acetylene yields, and no effort was made to determine losses of condensable or soluble products in the quench water.

The mass spectrometer analysis and the partial pressure of the product gas were used to calculate partial pressure products (f_n) for the pyrolysis subsystems:

$$C_2H_4 \rightleftarrows C_2H_2 + H_2 \quad (1)$$

$$C_2H_4 + 2H_2 \rightarrow 2CH_4 \quad (2)$$

At chemical equilibrium $f_n = K_n$, the equilibrium constant for the *n*th subsystem on assumption of ideal gas behavior. For the ethylene-acetylene-hydrogen subsystem, equilibrium was assumed ($f_1 = K_1$) and the temperature corresponding to K_1 defined as the effective reaction temperature; this temperature was then employed in determining the values of K_2. Equilibrium constants were calculated from the standard free energies of formation given by Rossini, *et al* (*20*).

Residence times (Θ) were computed on the basis of the total volume of product gas plus feed steam, the measured reactor total pressure, and the effective reaction temperature. The time required for the reactants to pass through the mixing chamber was not included in the residence time calculation.

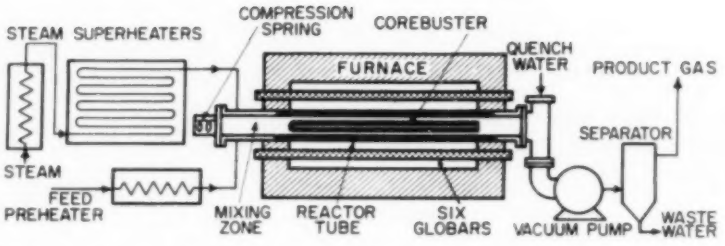


Figure 1. Flow diagram of pyrolysis apparatus.

Experimental results

In Figure 2, product gas yields and compositions obtained with the 3-inch O.D. corebuster are shown as functions of the effective reaction temperature. A, B, and C show data selected from operation at ½ atmosphere total pressure and approximately 0.03 second residence time for propane, butane, and natural gasoline. The data shown in D and E were selected from operation at 1 atmosphere total pressure and approximately 0.1 second residence time for natural gasoline and JP-4.

The composition of the product gas was nearly independent of feed properties. With increases in effective reaction temperature, the acetylene concentration passed through a maximum, the ethylene and methane concentrations decreased, and the hydrogen and carbon oxide concentrations increased. The acetylene maximum—12-14 mole % at ½ atmosphere total pressure—occurred at approximately 1800°F; at about 2000°F, ethylene virtually disappeared from the product gas.

The data in C and D for natural gasoline (Figure 2) illustrate to what extent the combined effects of lower pressure and shorter residence time favored acetylene over ethylene formation. At constant corebuster size, independent variation of residence time with pressure was not practical in these tests (the effects of variations in corebuster size are shown in Table 2).

Product yields. The volume of product gas increased rapidly with increases in reaction temperature for all feedstocks. For propane, butane, and natural gasoline, the acetylene yield at ½ atmosphere total pressure passed through a maximum of approximately 35 wt-% at 1800 to 1900°F effective reaction temperature; the yield from JP-4 was considerably lower up to 1800°F, but the range of operating conditions investigated was insufficient to define a maximum. The acetylene yield from natural gasoline and JP-4 at 1 atmosphere reaction pressure increased with increases in reaction temperature over the entire range of temperatures employed, and was substantially lower than at ½ atmosphere.

The ethylene yield from all of the feedstocks decreased with increases in effective reaction temperature and was negligible above 2000°F. With the 3-inch O.D. corebuster at 1600°F and ½ atmosphere, the ethylene yield from propane and butane was about 40 wt-%, and the combined yield of acetylene plus ethylene ranged from 50 to 60 wt-%. Higher combined yields were obtained with a 3.5-inch O.D. corebuster. Although increases in pressure lowered the combined yields (see natural gasoline data of Table 1), ethylene yields were substantially increased.

Methane production remained nearly constant over most of the range of operating conditions, indicating an approximate balance of methane-forming and methane-consuming reactions. However, at the highest temperatures investigated, methane production was somewhat reduced; this was probably related to the increase in hydrocarbon-steam or deposited carbon-steam reactions, as evidenced by greatly increased carbon oxide formation.

The formation of carbon indicated by the percentage of feed carbon not accounted for in the product gas stream (see Table 1) varied with feedstock molecular weight, reaction temperature, and pressure. Very little carbon was formed from propane or butane over the entire range of conditions employed. Substantial carbon formation was indicated for natural gasoline and JP-4. For these feeds, the amount of carbon formed was greater at higher pressure, and tended to increase with increase in reaction temperature.

The carbon not accounted for in

the product gas was not necessarily elemental carbon. Condensable hydrocarbons washed out by the quench water were not recovered.

Residence time. To observe the effect of residence time at constant pressure and constant mass throughput, the cross-sectional area of the reaction space was varied by changing the diameter of the corebuster from 3.0 to 3.5 inches O.D. In Table 2 the results of butane pyrolysis are compared for the two reaction volumes.

Increase in the size of the corebuster from 3.0 to 3.5 inches O.D. reduced residence time by nearly one half. Significant increases in the yields of both acetylene and ethylene were observed at the shorter residence time. Since use of the larger corebuster also increased the surface/volume ratio of the reactor by more than 200%, these results may not reflect the effect of residence time alone. However,

Table 1. Selected data for pyrolysis of natural gas liquids and petroleum distillates in 4-in. I.D. tube furnace with 3-in. O.D. corebuster.

Run No.	100-4	100-14	100-6	100-11	100-20	100-9	84-15A	84-17	84-23	84-32A	84-33
Feed	——Propane——			——Butane——			12 lb RVP Natural Gasoline			–JP-4– Overhead	–JP-4–
Operating Conditions											
Corebuster Diameter, in.	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Hydrocarbon Fed, lb/hr	19.75	18.17	9.97	33.25	20.56	18.06	17.10	17.09	16.45	20.50	19.12
Steam Fed, lb/hr	80.1	80.1	80.1	80.1	80.1	80.1	59.9	60.0	60.0	80.1	80.1
Steam/Hydrocarbon Feed Ratio, lb/lb	4.06	4.41	8.03	2.41	3.90	4.44	3.50	3.51	3.65	3.91	4.19
Temperature, °F											
Hydrocarbon Preheat	425	660	660	505	500	640	685	680	655	490	615
Steam Superheat	1735	1700	1745	1715	1760	1730	1770	1845	1870	1800	1735
Reactor Inlet	1360	–	1470	1365	1360	1450	1305	1400	1455	1320	1380
Reactor Tube, maximum	2390	2584	2690	2405	–	2540	2264	2352	2523	2357	2370
Exit Gas Stream	1550	1800	1840	1530	1545	1705	1630	1510	1650	1925	1570
Effective Reaction[a]	1661	1802	1965[b]	1594	1660	1815	1660	1655	1615	1798	1674
Total Pressure, atm	0.476	0.455	0.491	0.469	0.459	0.485	0.936	0.485	0.236	0.520	0.482
Partial Pressure of Product Gas, atm	0.120	0.125	0.122	0.157	0.128	0.138	0.232	0.121	0.0661	0.137	0.102
Residence Time, sec	0.0346	0.0300	0.0329	0.0316	0.0322	0.0314	0.0909	0.0471	0.0224	0.0349	0.0366
Operating Results											
Product Gas Rate, SCF/hr	563.7	635.2	554.3	842.7	649.3	669.1	414.0	418.3	490.8	603.8	451.3
Product Gas Yield, SCF/lb	28.5	35.0	55.6	25.3	31.6	37.0	24.2	24.5	29.8	29.5	23.6
Acetylene Production, SCF/hr	76.1	90.8	44.3	94.4	81.2	91.7	29.0	45.6	50.5	74.3	48.3
Acetylene Yield, wt%	26.5	34.4	30.6	19.5	27.2	34.9	11.7	18.4	21.1	24.9	17.4
Ethylene Production, SCF/hr	71.6	33.0	0	175.3	85.7	32.1	53.8	44.8	41.7	30.2	32.5
Ethylene Yield, wt%	26.9	13.5	0	39.1	30.9	13.2	23.3	19.4	18.8	10.9	12.6
Feed Carbon in Product Gas, wt%	95.4	87.8	98.9	97.3	102.0	93.2	80.1	82.9	86.4	78.5	67.7
Product Gas Analyses, Mole %[c]											
Acetylene	13.5	14.3	8.0	11.2	12.5	13.7	7.0	10.9	10.3	12.3	10.7
Diacetylene	0.1	0.2	0.1	0.1	0.2	0.2	0.0	0.1	0.2	0.1	0.1
Vinylacetylene	0.3	0.1	0.0	0.4	0.2	0.1	0.2	0.2	0.1	0.1	0.2
Propadiene and Methylacetylene	0.6	0.3	0.2	0.7	0.5	0.3	0.4	0.5	0.7	0.3	0.5
Ethylene	12.7	5.2	0.0	20.8	13.2	4.8	13.0	10.7	8.5	5.0	7.2
Higher Olefins and Diolefins	0.4	0.1	0.1	1.1	0.5	0.0	0.7	0.6	0.5	0.1	0.2
Benzene	0.8	0.4	0.4	0.7	0.4	0.5	1.8	1.6	0.9	1.5	1.9
Higher Aromatic	0.1	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.1	0.1	0.3
Methane	18.1	12.3	6.9	18.1	13.3	11.6	18.0	15.6	11.2	12.1	12.4
Higher Paraffins	0.3	0.0	0.0	0.5	0.2	0.1	0.2	0.1	0.2	0.0	0.1
Hydrogen	45.3	53.4	56.6	37.1	47.0	52.1	45.4	44.9	47.5	52.7	43.9
Carbon Monoxide	4.3	7.3	12.9	3.4	7.9	10.1	10.5	12.4	13.8	11.2	8.9
Carbon Dioxide	0.7	1.4	6.2	0.6	3.0	1.5	1.9	2.2	2.4	1.9	2.1
Nitrogen	2.8	5.0	8.6	5.2	1.1	5.0	0.7	0.0	3.6	2.6	11.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(a) Assuming chemical equilibrium between the components C_xH_y, H_2 and C_2H_4; effective reaction temperature corresponds to experimental value of equilibrium constant $K_1 = (C_xH_y)(H_2)(Px)/(C_2H_4)$, where the concentrations are in mole fractions, and Px is the partial pressure of product gas in atmospheres.

(b) Since no ethylene was measured in the product gas for this run, the effective reaction temperature was obtained from a correlation with maximum tube temperature.

(c) Mass spectrometer analyses.

several investigators found no effect of surface on the pyrolysis of methane (*6, 7, 9*).

Discussion. The calculated effective reaction temperatures giving significant yields of acetylene (35 wt-%) are considerably below reported temperatures for similar data on vapor-phase thermal cracking of low molecular weight hydrocarbons (*2-5, 8, 10, 22, 23, 24*). It has been customary to regard a measured temperature, normally representative of reactor wall temperature, as the true reaction temperature. However, at the short residence times required to produce acetylene, close approach to indicated wall temperature is not assured. The assumption of efficient heat transfer due to turbulent flow conditions made by some of the investigators may not be justified since Reynolds numbers ranged from order of magnitude 10 to 1000 in these studies (*23, 24*). In addition, as long as the rate of acetylene formation is substantial, the endothermic reaction heat requirements will be high.

Because of the complexity of the problem of computing temperature profiles in a pyrolysis flow system under the reaction conditions employed in acetylene production, no attempt was made to confirm the calculated effective reaction temperatures by heat transfer calculations. This parameter is, therefore, entirely empirical, although its use can be justified indirectly. This contrasts with an earlier pyrolysis study in a 2.5-inch I.D. reactor of 42-inch heated length, in which attainment of ethane-ethylene-hydrogen equilibrium at measured temperatures of 1300° to 1700°F was confirmed for residence times above one second; calculated reaction mass temperatures at laminar flow conditions were found to closely approach tube wall temperature in the major portion of the reactor volume, neglecting radiant heat transfer and endothermic heat of reaction (*12, 14*). In the present study, devia-

Table 2. Effect of corebuster diameter on pyrolysis of butane.

Run No.	84-35	100-24	100-10	100-23
Corebuster Diameter, inches	3.0	3.5	3.0	3.5
Conditions				
Total Pressure, atm	0.489	0.474	0.508	0.556
Partial Pressure of Product Gas, atm	0.147	0.135	0.150	0.140
Steam/Butane Feed Ratio, lb./lb.	3.02	2.77	3.26	3.82
Effective Reaction Temperature, °F	1586	1562	1695	1692
Residence Time, sec	0.0343	0.0175	0.0342	0.0201
Results				
Product Gas Yield, SCF/lb.	27.2	23.0	28.7	27.0
Acetylene Yield, wt %	16.7	21.8	28.1	34.7
Ethylene Yield, wt %	39.5	45.2	26.4	30.0
Product Gas Analysis, mole %				
Acetylene	8.9	13.8	14.2	18.7
Diacetylene	0.1	0.2	0.2	0.2
Vinyl Acetylene	0.2	0.4	0.3	0.3
Propadiene and Methyl Acetylene	0.4	0.7	0.5	0.5
Ethylene	19.6	26.5	12.4	15.0
Higher Olefins and Diolefins	2.4	1.2	0.3	0.2
Benzene	0.5	0.8	0.8	0.8
Higher Aromatics	0.2	0.2	0.1	0.2
Methane	14.4	17.7	15.8	16.7
Higher Paraffins	1.8	0.4	0.2	0.2
Hydrogen	42.9	35.8	43.1	42 8
Carbon Monoxide	5.4	1.9	5.6	3.2
Carbon Dioxide	1.4	0.2	0.9	0.5
Nitrogen	1.8	0.2	5.6	0.7
Total	100.0	100.0	100.0	100.0

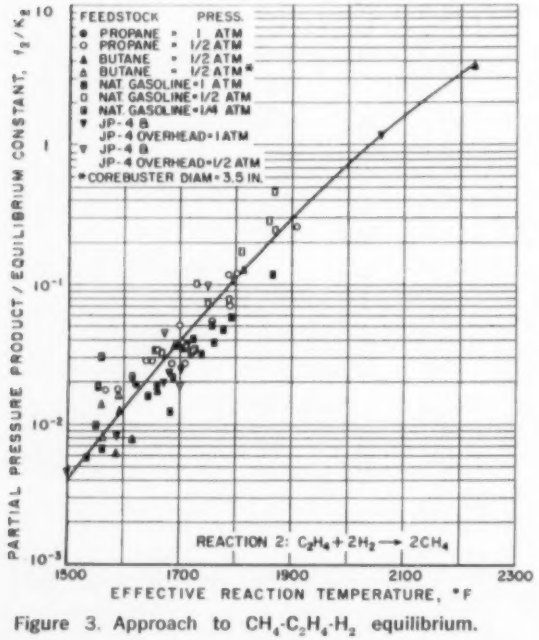


Figure 3. Approach to CH_4-C_2H_4-H_2 equilibrium.

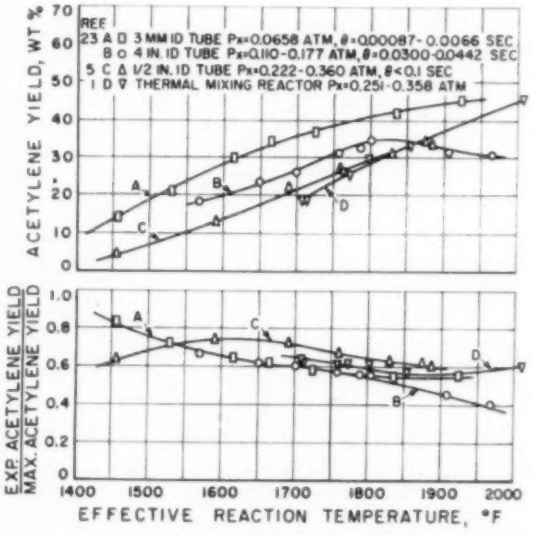


Figure 4. Comparison of the yields of acetylene from propane in different pyrolysis apparatus. (Max. C_2H_2 yield based on C_2H_4-C_2H_2-H_2 equilib. prod. distribution.)

tions of 600° to 800°F existed for typical operation with propane between the measured reactor tube wall temperature and the effective reaction temperature.

The use of effective reaction temperatures in the absence of reliable temperature measurements is supported by the behavior of the methane - ethylene - hydrogen subsystem (Figure 3). This subsystem represents the overall reaction corresponding to reactions 3 and 4 below, at $i = 2$:

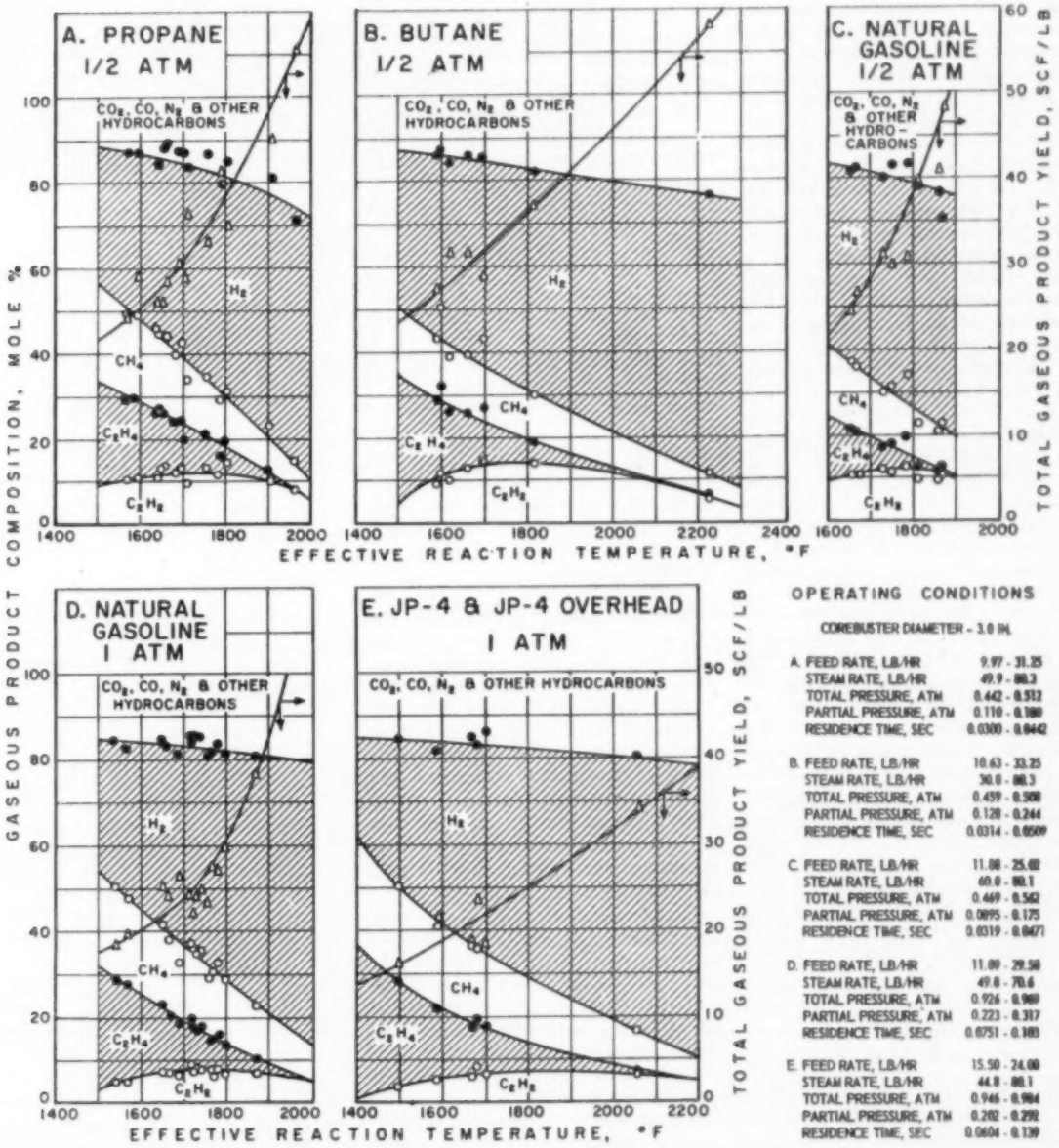
$$C_iH_{2i} + H_2 \rightleftharpoons C_iH_{2i+2} \quad (3)$$

$$C_iH_{2i+2} + H_2 \rightarrow CH_4 + C_{i-1}H_{2i} \quad (4)$$

where $i = 2, 3 \ldots$

The above reaction scheme — relatively slow hydrogenolysis of gaseous paraffins in equilibrium with olefins of equal carbon number — was found to best represent the stoichiometry of methane formation in a variety of high-temperature pyrolysis and hydrogenolysis systems (*12, 14, 21*). In addition to ethane-ethylene-hydrogen equilibrium, approach to equilibrium of higher molecular weight paraffin-olefin-hydrogen subsystems and of the ethylene-acetylene-hydrogen subsystem was also indicated.

Figure 3 and similar plots for the benzene-acetylene and graphite-hydrogen-acetylene subsystems show that over the relatively narrow range of residence times (0.02 to 0.14 second) employed in this study, secondary pyrolysis reactions approach equili-



OPERATING CONDITIONS

COREBUSTER DIAMETER - 3.0 IN.

A.	FEED RATE, LB/HR	9.97 - 31.25
	STEAM RATE, LB/HR	49.9 - 88.3
	TOTAL PRESSURE, ATM	0.442 - 0.512
	PARTIAL PRESSURE, ATM	0.110 - 0.180
	RESIDENCE TIME, SEC	0.0300 - 0.0442
B.	FEED RATE, LB/HR	10.63 - 33.25
	STEAM RATE, LB/HR	30.0 - 88.3
	TOTAL PRESSURE, ATM	0.459 - 0.509
	PARTIAL PRESSURE, ATM	0.128 - 0.244
	RESIDENCE TIME, SEC	0.0314 - 0.0509
C.	FEED RATE, LB/HR	11.88 - 25.02
	STEAM RATE, LB/HR	60.0 - 98.1
	TOTAL PRESSURE, ATM	0.469 - 0.562
	PARTIAL PRESSURE, ATM	0.0895 - 0.175
	RESIDENCE TIME, SEC	0.0319 - 0.0471
D.	FEED RATE, LB/HR	11.09 - 29.50
	STEAM RATE, LB/HR	49.8 - 78.6
	TOTAL PRESSURE, ATM	0.926 - 0.969
	PARTIAL PRESSURE, ATM	0.223 - 0.317
	RESIDENCE TIME, SEC	0.0751 - 0.103
E.	FEED RATE, LB/HR	15.50 - 24.00
	STEAM RATE, LB/HR	44.8 - 88.1
	TOTAL PRESSURE, ATM	0.946 - 0.984
	PARTIAL PRESSURE, ATM	0.202 - 0.292
	RESIDENCE TIME, SEC	0.0604 - 0.139

Figure 2. Product gas compositions and yields.

brium uniformly with increases in effective reaction temperature. The effect of feedstock properties is small; this is characteristic of pyrolysis severities at which complete conversion has been achieved and gaseous product composition is determined by secondary reactions (*14, 18*). There is, however, a tendency towards systematic scattering of data points obtained at various total pressure levels (corresponding to partial pressures ranging from 0.04-0.32 atmospheres) which indicates a basic inadequacy of the correlation procedure employed.

In Figure 3, increases in deviation of f_2/K_2 from unity (equilibrium) with decreases in effective reaction temperature, are of about the order of magnitude anticipated from previous work (*12, 14*). If it were assumed that the true reaction temperature was approximated by the measured reactor temperature, the values of f_2/K_2 would have exceeded unity over the entire range of operating conditions employed. The same appears to be true for extensive paraffin and olefin pyrolysis data obtained in a 3 mm I.D. reactor (*23, 24*). This supports the use of the lower effective reaction temperatures based on assumption of ethylene-acetylene-hydrogen equilibrium, since no acceptable mechanism for the consistent formation of abnormally high amounts of methane (compared to formation of ethylene and hydrogen) from widely differing feedstocks can be formulated. Thus, the assumption that the ethylene-acetylene-hydrogen subsystem is in flowing equilibrium under the operating conditions employed in this study seems to be in better agreement with the observed results than the assumption that acetylene is the product of a relatively slow ethylene dehydrogenation step (*10, 22*). The latter concept is based largely on pyrolysis data which intend to show the effect of residence time on gaseous product distribution at constant reaction temperature, but appear actually to show the combined effects of increases in temperature and residence time (*22, 23, 24*).

Increasing the yield of acetylene in actual practice

Experimental data in the literature on acetylene production were obtained in apparatus of various types and over a wide range of operating conditions. Comparison of these data on the basis of the effective reaction temperature as a common parameter, rather than on the basis of the reported measured temperatures, provides an interesting view of the process. Figure 4 shows the experimental yields of acetylene from propane obtained in several tubular reactors (*5, 23*) and from the Eastman process where the hydrocarbon feed is cracked by mixing with a stream of hot combustion products (*1*). For the data of Hasche (*5*), the total reactor pressure was assumed to be one atmosphere. For the Eastman data (*1*), the partial pressure of the product gas was computed on the basis that the fuel was completely converted to carbon dioxide and water, which were considered to be diluents.

Figure 4 illustrates the similarity in results although operating conditions differed widely. The upper set of curves reflect the expected effect of pressure on reaction 1 over most of the temperature range. The close agreement between curves C and D is especially interesting; although the partial pressure of the product gas was the same for both, the process techniques were quite different. It is also interesting to note that all the data for curve A were obtained at a single measured reactor temperature (2552°F).

In the lower set of curves, the maximum yield of acetylene was calculated by assuming complete feedstock conversion to equilibrium amounts of acetylene, ethylene, and hydrogen corresponding to reaction conditions. Over most of the range of effective reaction temperature the "efficiency" of the various processes was about the same although some displacement of the curves due to the effect of residence time was expected. Deviations at the high and low temperature extremes are probably the result of incomplete conversion and steam-hydrocarbon reactions, respectively. Similar plots of ethylene data from the same sources show the same trends as the acetylene data of Figure 4.

It appears that the yield of acetylene obtained in practice by thermal cracking has been limited by the same factors, regardless of the operating conditions or process techniques employed. The distribution between acetylene and ethylene varies only with conditions affecting the apparent equilibrium of reaction 1. Since the rates of acetylene and ethylene formation appear to be much greater than those of competing products, the key to increased acetylene yields is the attainment of high pyrolysis severity at high temperature (true reaction temperature) within a residence time short enough to minimize side reactions. It does not seem likely that this can be accomplished when the supply of heat depends upon transfer from a reactor wall or other surface to the gas stream. Processes in which the heat requirements are met by mixing a highly preheated carrier gas with the feedstock, as exemplified by the Eastman process, probably hold the greatest promise for increased acetylene yields.

ACKNOWLEDGMENT

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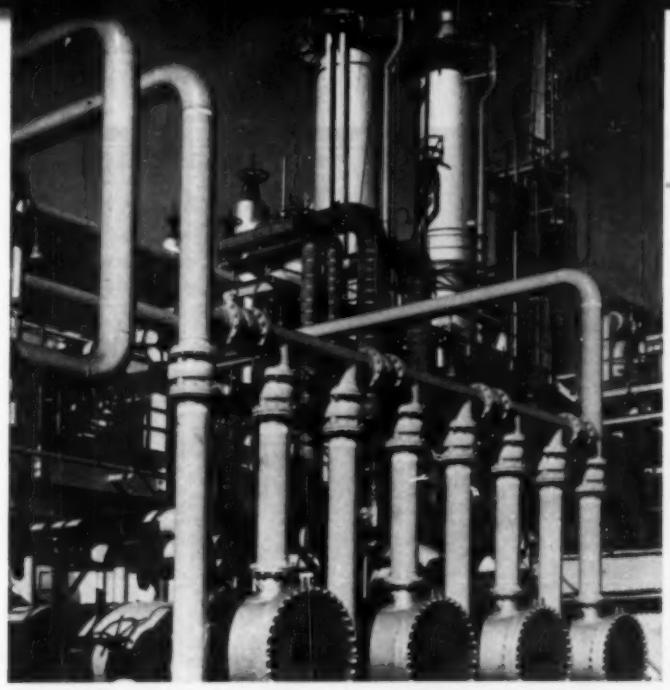


Part of the acetylene facilities at Monsanto's Texas City plant.

H. C. SCHUTT
Consulting Engineer
Boston, Mass.

High purity ethylene via the solvent extraction route

Acetylene impurities can be economically removed from olefin stream by use of selective solvents. Where acetylene concentration is high this process can be adapted to recover the acetylene as a product.

FOR THE POLYMERIZATION or copolymerization of olefins, in general, a very high purity of the monomers is required. Acetylenes and diolefins as well as acid gases such as carbon dioxide, hydrogen sulfide and carbonyl sulfide can only be tolerated in trace quantities, measured in parts per million (ppm). The catalytic oxidation of ethylene and propylene impose similar low tolerances of impurities in order to avoid deactivation or poisoning of a sensitive and expensive catalyst. Acetylene concentrations in so-called high purity ethylene and propylene products usually have to be below 10 ppm, and frequently less than 5 ppm, for certain synthesis processes.

Methods for acetylene removal

Most ethylene is produced by high temperature cracking of ethane, propane, butane and distillate oil fractions. The conversion products contain varying amounts of acetylenes depending upon the pyrolysis temperature level, depth of cracking and the steam dilution. Typical compositions are given in Table 1.

The phase equilibria of the system: ethane-ethylene-acetylene has been investigated (*12*) and it is generally established that the acetylene, when present in the C_2 fraction in concentrations of 0.5 to 2.0 percent, remains mostly with the ethylene in the separation between ethylene and ethane by fractionation. At pressures in the order of 250-300 psia, conditions prevailing in many commercial ethylene-ethane fractionators, the equilibrium constant for acetylene is actually higher than that for ethylene over a relatively wide temperature range, —50 to 150°F.

In the separation of a propylene-propane product from C_4 and heavier hydrocarbons, the propadiene remains essentially with the C_3 fraction while only approximately 50 percent of

the methylacetylene will be found in the overhead of a depropanizer.

When the petrochemical industry had its beginning some 28 to 30 years ago, acetone was mainly considered as a selective absorption medium for the removal of acetylene present in ethylene-bearing hydrocarbon gases which were produced by vapor-phase cracking of petroleum distillates or high temperature pyrolysis of LPG derived from natural gas. The processing scheme illustrated in U.S. Patent 2,250,925(*1*) may be considered as typical for this absorption method, involving a combination of numerous process steps in order to hold down losses of ethylene and of the relatively volatile solvent. Such absorption systems for acetylene separation were mainly used in ethylene manufacturing plants installed prior to the last war.

Catalytic refining methods came into general use in the petroleum industry during the last war and are widely used in the manufacture of organic chemicals. The ethylene-bearing, cracked or pyrolysis, gas contains a considerable amount of hydrogen and it was a natural development to employ catalytic hydrogenation for the conversion of acetylene in the ethylene-bearing gas stream. Highly selective catalysts were found and prepared to accomplish this. Most large ethylene plants built since the war incorporate facilities for acetylene removal by catalysis. The raw ethylene-bearing gas stream or the concentrated C_2 stream may be subjected to this hydrogenation step, requiring specific catalysts for each application.

In the acetylene removal process treating the raw pyrolysis gas stream, the catalyst requires periodic regeneration involving steam stripping, oxidation, and reduction to restore its activity and selectivity. Considerable equipment is required for this reactivation in addition to the apparatus serving the actual hydrogenation process. Thus, investment and operating costs of this acetylene removal step are appreciable, especially in view of the relatively high cost of catalyst. For small-capacity ethylene plants, these costs appear to be especially high and of greater economic significance than for the larger installations. Therefore, the removal of acetylene by absorption, a well-established operation, is receiving consideration again. It seems to have economic advantages if the operation is practiced at low temperature on the concentrated ethylene-ethane or the ethylene product stream, and the refrigeration requirements are supplied by the propane or ammonia system at the temperature levels employed in the primary ethylene recovery unit.

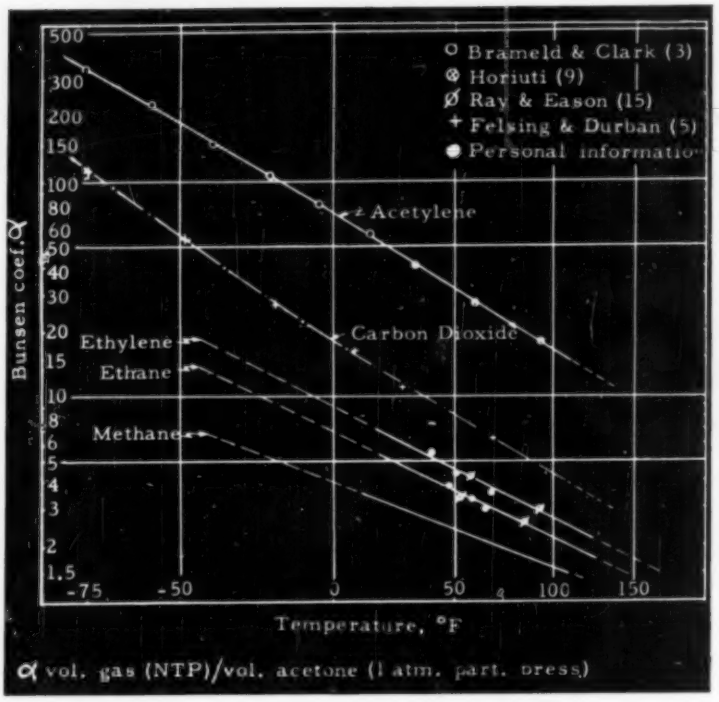


Figure 1. Solubility of gases in acetone (Bunsen coefficient).

Solvents for acetylene

There are numerous chemical compounds which exhibit a high solvent power for acetylene and a high selectivity between ethylene and acetylene. These solvents may be classified into two groups, as shown on Table 2. The more volatile compounds are those boiling below 212°F (the boiling point of water) and the less volatile materials are those boiling considerably above this temperature. The latter chemicals are employed mainly in treating gas streams at relatively low pressures and when actual recovery of pure acetylene is also to be accomplished. The low boiling solvents are preferred when acetylene

Table 1. Composition of C_3 and lighter fraction of high temperature pyrolysis gases (at 7.5 to 9 psig coil outlet pressure)

Feed Stock:		Ethane	Propane	Propane-n-Butane Propylene		Naphtha 95 to 225°F
Severity of Cracking						Maximum Severity
% Conversion		62.5	87.5	85 (C_3H_8)	95.0	70.8 wt % C_4 & lighter
Steam Dilution:						
Mol/mol of feed		0.30	0.42	1.10	0.95	4.75
Coil Outlet Temperature, °F		1515	1495	1503	1498	1425
Composition:	B.Pt., °F	Mol %	Mol %	Mol %	Mol %	Mol %
H_2+CH_4		41.73	50.55	41.88	51.00	48.53
C_2H_4	−157.0	33.53	26.35	25.75	29.10	28.75
C_2H_6	−127.5	23.95	7.86	3.94	6.72	7.62
C_2H_2	−119.0	0.18	0.23	0.32	0.45	0.49
C_3H_6	−53.9	0.37	7.48	21.89	11.52	13.21
C_3H_8	−43.7	0.23	7.25	5.60	0.88	1.10
C_3H_4 (Propadiene)	−30.1	0.01	0.07	0.16	0.08	0.09
C_3H_4 (Methylacetylene)	−9.8		0.21	0.46	0.25	0.21
		100.00	100.00	100.00	100.00	100.00

is removed as a waste product and absorption can be performed at elevated pressures and subatmospheric temperatures. The low boiling solvents are thermally stable and the stripping of the solute is a relatively simple and low cost operation. The high boiling compounds are, in general, thermally less stable, tend to decompose at their atmospheric boiling points, and have to be stripped under vacuum, which involves increased equipment and operating costs.

When considering acetylene solubility, freezing point of the solvent, its stability and cost as well as various operating factors, it becomes almost obvious from Table 2 that acetone is the best solvent in the category of the more volatile materials for the purpose of removing acetylene from the concentrated C_2 fraction, or the ethylene product at relatively low temperatures. From the less volatile solvent one would, no doubt, choose dimethylformamide, especially when acetylene is to be separated and recovered as a product.

There exist rather extensive solubility data (*3, 5, 8, 9, 10, 13, 15, 16*) of hydrocarbons in acetone and the unit processes and operations involved are proved in practice and amenable to more or less rigorous chemical engineering calculations or design methods.

Table 2. Selective solvents for acetylene separation and recovery

Solvent — Name	Solvent — Formula	Atm. Boil. Point; °F	Melting Point; °F	Spec. Grav. @60 °F/4°C	C_2H_2 Solubility @60°F NCF of gas CF of Solv. (at 1 atm.) part. press.)
Methylal	$CH_2(OCH_3)_2$	111.2	−156	0.856	27.2 (10)
Ethyl Formate	$HCO_2C_2H_5$	129.2	−110.2	0.926	21.5 (10)
Acetone	CH_3COCH_3	133.7	−138	0.794	27.1 (9,16)
Methyl Acetate	$CH_3CO_2CH_3$	134.8	−145.5	0.928	26.8 (10)
Ethyl Acetate	$CH_3CO_2C_2H_5$	170.8	−116.4	0.904	22.7 (10)
Methyl Propionate	$CH_3CH_2CO_2CH_3$	175.4	−125.5	0.919	16.6 (9)
Acetonitrile	CH_3CN	178.8	− 46.0	0.785	17.8 (15)
1,4 Dioxane	$(CH_2OCH_2)_2$	215.0	+ 53.0	1.037	19.7 (11)
Morpholine	$CH_2OCH_2NH(CH_2)_2$	262.2	—	1.004	19.2 (11)
Propionic Acid	$CH_3CH_2CO_2H$	285.8	− 7.5	0.995	26.8 (9)
Dimethyl Formamide	$HCON(CH_3)_2$	307.0	− 78.0	0.955	40.3 (4)
Acetonyl Acetone	$CH_3CO(CH_2)_2COCH_3$	379.4	+ 15.8	0.973	17.6 (11)
Butyrolactone	$(CH_2)_3COO$	402.8	− 62.0	1.131	17.1 (13)
Methyl Pyrrolidone	$(CH_2)_3NCOCH_3$	395.6	− 11.5	1.033	44.2 (7)

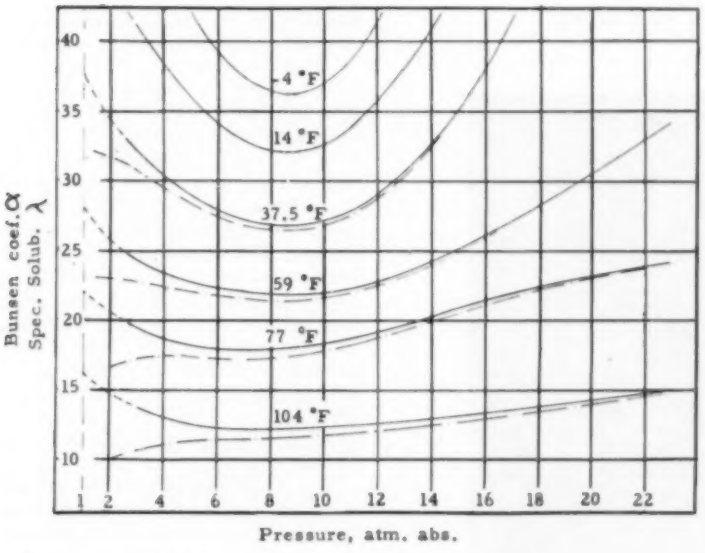
Solubility data and their use

The conventional or classical expression of solubility of a gas in a liquid solvent is the volume of gas dissolved by unit volume of liquid at a given temperature and partial pressure of the gas. Temperature has, of course, a marked effect on the amount of gas absorbed by a solvent, irrespective of its affinity or preferential solvent power for a specific compound. The best known gas solubility coefficient is probably the Bunsen factor, α, precisely defined as: volume of solute (measured at 32°F and 1 atm. abs.) that is dissolved in one volume of the solvent (measured at the temperature and pressure of the experiment) when the partial pressure of the solute is 1 atm. abs.

In many instances the solubility is expressed by the Ostwald coefficient, simply defined as: volume of gas dissolved in a unit volume of solvent. Both volumes are taken at the existing temperature and pressure; therefore, the coefficient is independent of the partial pressure when Henry's law is valid. Other scientists (9) report solubility data at a given temperature in terms of volume per unit volume of solution, taking the incremental volume of the absorbed constituents or a factor of dilatation into consideration.

The various solubility concepts or definitions must be fully understood in order to utilize the available data. Friend and Adler (6) have made a valuable contribution to chemical engineering science in formulating the relationship between the various solubility factors or coefficients used or reported in the literature and their conversion into Henry's law and equilibrium constants applicable in conventional process calculations. It seems both expedient and less conducive to error to express the solubilities reported in the literature in terms of the Bunsen coefficient, and Figure 1 shows the solubility in acetone of acetylene and other constituents of the unrefined C_2 or ethylene product stream, over a temperature range encountered in the extraction process.

The commercial application of this



α vol. gas (NTP)/vol. acetone (1 atm. part. press)
λ vol. gas (NTP)/vol. acetone (1 atm. total press)

Figure 2. Solubility of acetylene in acetone (effect of pressure).

type of solvent extraction is rarely done at pressures and concentrations where the solubility coefficients were obtained and can be accepted as valid. Process streams are either at a higher pressure or the process deliberately employs a higher absorption pressure in order to take advantage of the higher solubility at elevated pressure. The question is, then, how much higher is the Bunsen factor at superatmospheric pressure? We know that the PVT state of the gases or vapors at elevated pressures is not defined by Boyle's law nor are Raoult's and Henry's laws for ideal solutions strictly obeyed.

Solubility measurements at elevated pressures have been made by Berthelot & Vieille (*2*) and Siller (*17*) indicating no pronounced effect of pressure on the Bunsen coefficient. The later studies of Rauert(*14*) indicate the validity of Henry's law at elevated pressure and relatively high solute concentrations; but there is considerable disagreement between the findings of these early investigators. In recent years both the effect of pressure and the solute concentration in the acetylene-acetone solutions have been experimentally explored by Holemann and Hasselmann(*8*). An evaluation of their data in terms of solubility coefficient vs. pressure and temperature is shown in Figure 2. The wide variation of the Bunsen coefficient with pressure will be noted. It decreases rapidly with pressure, reaches a minimum at between 7-9 atm. and then rises, so that at approximately 18 atm. the basic or normal value (for 1 atm. abs. partial pressure) is attained again. Both the Bunsen and Ostwald coefficients are shown (the latter being supposedly independent of pressure) and it is interesting to observe the deviations in the lower pressure and higher temperature range, principally caused by the vapor pressure of the relatively volatile acetone solvent. It can also be shown that the data do not obey Henry's law, and that the Henry's law constant varies by a factor of about two as the pressure is increased from 1 to 30 atm. at a given temperature.

Commercial applications are concerned with a multicomponent rather than binary system, and the variation of α with pressure for the components of lower solubility has to be established experimentally. They are not as pronounced as those for the more soluble constituents, as shown for ethylene in Figure 3 (*13*).

Having thus verified the solubility coefficient over the pressure and temperature range encountered in the acetylene removal system, one can proceed to relate the Bunsen coefficients to Henry's law constant or convert them to conventional K values. The molal ratio of the solute and the solvent, X_i can be related to the solubility factor, α, by the following expression:

$$X_i = \frac{P_i \times \alpha_i}{359} \times \frac{M_s}{\rho_s \times 62.42} = \frac{P_i \times \alpha_i \times M_s}{\rho_s \times 22{,}400} \quad (1)$$

Henry's law constant for the binary solute-solvent system is given by:

$$H_i = \frac{P_i}{x_i} = P_i \frac{1 + X_i}{X_i} = \frac{22{,}400 \times \rho_s \times (1 + X_i)}{\alpha_i \times M_s} \quad (2)$$

The equilibrium constant for the binary system is similarly given by:

$$K_i = \frac{P_i}{\pi} \times \frac{1 + X_i}{X_i} = \frac{22{,}400 \times \rho_s \times (1 + X_i)}{\pi \times \alpha_i \times M_s} \quad (3)$$

When dealing with a multicomponent instead of a binary system, the less soluble constituents reduce the mol fraction or partial pressure of the key constituent, and Equations 2 and 3 become:

$$H_i = \frac{22{,}400 \times \rho_s}{\alpha_i \times M_s}\left(1 + X_i + \sum_1^n X_n\right) \quad (4)$$

and

$$K_i = \frac{22{,}400 \times \rho_s}{\pi \times \alpha_i \times M_s}\left(1 + X_i + \sum_1^n X_n\right) \quad (5)$$

The expressions given above for Henry's law and equilibrium constants were derived assuming that the constituents absorbed by the solvent do not exert a further absorptive power, as is the case in many absorption processes such as the recovery of higher molecular weight fractions from natural gas by oil absorption. Although the method used here is not generally accepted (*6, 18*), an analysis of existing equilibrium data indicates that it is valid for absorption of acetylene in acetone, within the ranges of concentration of practical interest. This assumption seems also justified inasmuch as we are dealing with a system in which there is a large affinity of the solvent molecule for unsaturated solute molecules. It is certainly not true that the highly soluble key component, acetylene in this case, is nearly as soluble in dissolved ethylene and ethane as in the solvent itself.

The partial pressure of the solvent is to be considered, especially when dealing with a rather volatile solvent:

$$P_s = \gamma P_s \times x_s = \frac{\gamma P_s}{\left(1 + X_i + \sum_1^n X_n\right)} \quad (6)$$

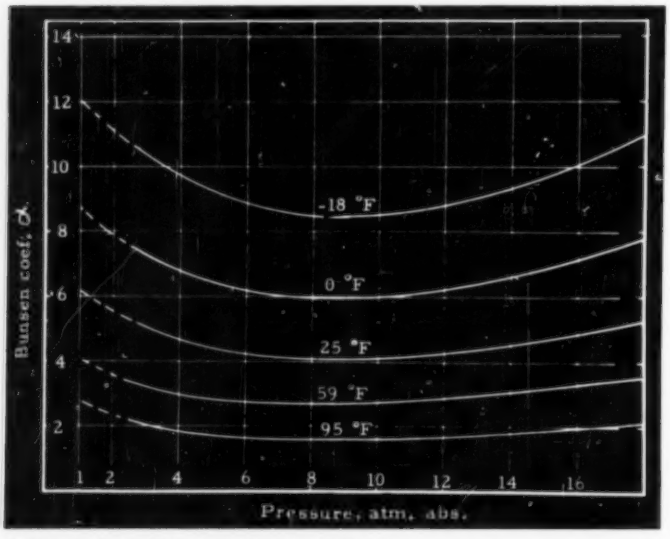


Figure 3. Solubility of ethylene in acetone.

and the equilibrium constant:

$$K_s = \gamma \times \frac{P_s}{\pi} \qquad (7)$$

Having thus defined the method of deriving conventional K values from solubility data, one can construct charts showing K as a function of pressure, temperature and composition. The basic correlation of experimental data, such as shown in Figures 2 and 3, forms the starting material. For constituents of the gas of relatively low solubility and present only in small concentration, such as ethane and methane in an ethylene product stream, it seems permissible to use the basic Bunsen coefficient, Figure 1, for all pressures. As an example, a correlation of K vs. temperature and pressure is presented for acetylene in Figure 4. Similar charts may be prepared for the less soluble constituents.

Process calculations

A separation process involving absorption, fractionation, vaporization and condensation requires the determination of numerous vapor-liquid equilibria, in addition to dew point and bubble point calculations with which the chemical engineer is generally familiar.

When attempting to make a sharp separation between acetylene and ethylene, or to recover acetylene as a product of relatively high purity, tray-to-tray equilibrium calculations are required which involve the knowledge of heats of absorption to establish the temperature change. Solubility data themselves are the best source for the heats of absorption of hydrocarbons in acetone which can be determined by an equation analogous to the Clausius-Clapeyron equation:

$$\ln \frac{\alpha_1}{\alpha_2} = \frac{MH_s}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \qquad (8)$$

or

$$H_s = \frac{R}{M} \times \ln \frac{\alpha_1}{\alpha_2} \times \frac{T_2 \times T_1}{T_2 - T_1} \qquad (9)$$

The use of this equation presupposes that the specific volume of the vapor greatly exceeds the partial volume of the solute in the liquid. This is the case in all process phases encountered in an acetone solvent extraction unit, where pressures are far below that of the critical pressure of any constitutent handled in the system. Table 3 contains some numerical values of heats of solutions.

Process design

The separation of acetylene by a selective solvent appears attractive for relatively small ethylene plants in comparison with the use of selective catalytic hydrogenation of acetylene in the raw gas stream. Also, there are cases where relatively large ethylene production units have been installed without provision for the removal of acetylenes. Product diversification, such as adding the manufacture of ethylene oxide, requires an essentially acetylene-free ethylene feed and the solvent treatment of part of the ethylene production appeared to be the most economical way of meeting this requirement. Figure 5 may serve as an illustration of the process design of such an adjunct unit to an ethylene plant, based on using acetone as the absorption medium.

Table 3. Heats of solution in acetone

Compound	Temperature Range; °F	Heat of Solution H_s; BTU/LB
Acetylene	0–100	283.5
Ethylene	0–100	215.0
Ethane	0–100	195.5
Methylacetylene	0– 50	284.0
	50–100	243.0
Carbon Dioxide	0– 50	167.5
	50–100	161.0

Referring to Figure 5, the ethylene feed stream obtained from a conventional ethylene-ethane fractionator enters the absorber at a temperature of —20°F and 265 psig and flows upward countercurrent to the descending solvent. The most effective means of contacting are packings such as small Pall rings, Berl saddles, "Intalox", "Star"(*19*), or various forms of expanded metal. All of these offer high interfacial surface areas between liquid and vapor, and highly turbulent vapor flow to intensify the gas film diffusion rate which controls the absorption process.

The rich solvent flows by gravity through a heat exchanger (lean solvent) and a heater to a flash chamber where a considerable quantity of the lesser soluble constituents is flash-vaporized and directed back to the absorber as recycle. This recycle stream carrying a considerable amount of solvent vapors is cooled, first by water, then by a refrigerant to condense most of the solvent vapors and bring the temperature down to approximately that of the fresh feed to the absorber.

The solution remaining in the Temperature Flash chamber, which is still saturated with absorbed hydrocarbons at the existing temperature and pressure, flows to a second flash chamber maintained at a reduced pressure. This effects a further release of absorbed constituents, mainly ethylene, desirable as a product. The vapors leaving the top of this medium-pressure flash chamber are cooled, principally to condense solvent. The remaining vapors are recompressed to the absorber pressure by a moving liquid type centrifugal

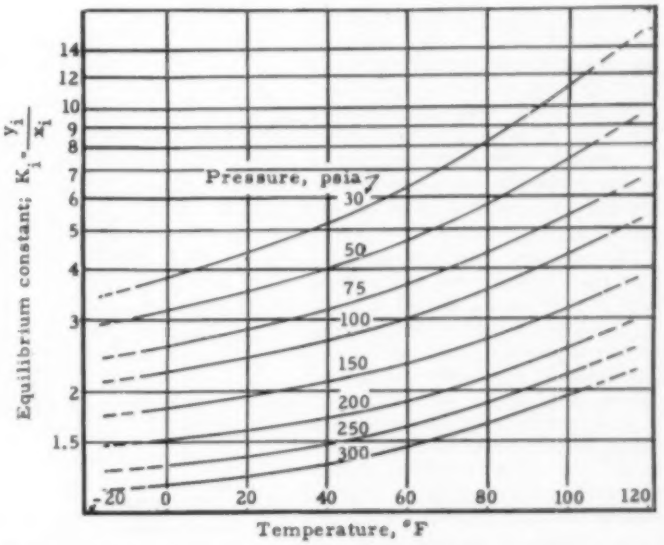


Figure 4. Equilibrium constant for acetylene in acetone-acetylene system.

compressor employing the solvent as sealing fluid. This constitutes a safe way of handling this recycle gas stream of relatively high acetylene concentration.

The bottoms of the "reduced pressure" flash chamber flow to the solvent stripper operated at a pressure in the order of 25 to 30 psia. The column is equipped with a bottoms reboiler and a reflux condenser. The reboil rate is sufficiently high to insure essentially complete removal of the acetylene from the solvent. The reflux condenser is water cooled and its duty is simply determined by heat balance commensurate with the required boil-up rate or heat input into the bottoms which can be supplied by low pressure steam. The overhead stream leaving the reflux condenser is passed through a final condenser where refrigerant is used as the cooling medium producing an effluent temperature in the order of —30°F at which the solvent fraction of the residual overhead vapors is almost completely condensed. The liquid from the final condenser is returned by gravity to the feed section of the stripper column. The uncondensed vapors from the final cooler constitute the net acetylene contained in the ethylene feed stream, plus some ethylene which must be accepted as an unavoidable loss. This waste gas is usually mixed with a larger fuel gas stream for its final, safe, and useful disposal.

The lean solvent from the bottom of the stripper is pumped back to the absorption section through the aforementioned rich-lean-solvent heat exchanger, attaining a temperature in the order of 0°F. It is then contacted with the pure ethylene product stream from the top of the absorber and thus saturated with hydrocarbons. The heat of solution is removed in a specially designed refrigerated cooler, where the saturation process, initiated by a venturi mixer, is also carried to completion.

The saturated solvent is separated from the ethylene vapor and accumulated in a drum, on the top of which is mounted a short fractionating section equipped with bubble cap type trays. In this section the acetone carried along by the ethylene vapors is deflected by ethylene reflux produced by refrigeration at the —40°F level. The pure ethylene product leaves the reflux condenser at approximately —30°F, which corresponds to a pressure of approximately 245 psia. In the event there are product purity requirements which limit the acetone and water content of the ethylene product to a few parts per million, a set of adsorption chambers may be provided, as indicated on the flow diagram, Figure 5, using such extractive media as charcoal or molecular sieves.

Table 4. Performance of commercial unit.
(Producing 100,000 lb./day of Ethylene)

	Raw Ethylene Feed Mol/Day	Ethylene Product Mol/Day	Ethylene Product Mol %	Acetylene Stream Mol/Day
CH_4	39.6	39.6	1.09	..
C_2H_2	49.5	<10 ppm	..	49.5
C_2H_4	3,576.3	3,565.0	97.61	11.3
C_2H_6	45.7	45.7	1.25	..
C_3+	1.9	1.7	0.05	0.2
	3,713.0	3,652.0	100.00	61.0
Acetone				0.11
"	lb./day	(process loss)		6.4
Lean Solvent circulation:			12.0 gpm	
Utilities: (Quantities per stream day)				
Steam (Low pressure, 10 psig)				lb. 52,000
Cooling water (Incl. refrigerant condensation)				gal. 90,000
Electricity (Recycle compr., pumps, instr. & light)				kwh. 475
Refrigeration (Increm. fuel gas requirements)				M Btu. 21,600
Solvent Make-up (Including leakage losses)				gal. 2-3

The ethylene saturated solvent is then pumped to the top of the absorber which now functions as a "rectifying" absorber. As the solvent descends in the column, the absorbed ethylene is partially replaced by the more soluble acetylene. The net heat effects from equilibrium to equilibrium step, as dictated by the concentration gradient, are relatively small and the column operates essentially under isothermal conditions. Table 4 gives some general performance data for the system just described.

For a unit treating a raw ethylene product stream to yield 100,000 lb of ethylene per day as a 97.5% pure product the equipment is quite small, the absorber being less than 2 ft. in diameter. The unit compactly arranged, adjacent to the raw ethylene recovery plant and permitting a simple tie-in with its propane or propylene refrigeration system, should not cost more than $175,000 if construction is performed at the same time as the installation of the ethylene plant proper. This investment figure covers the equipment indicated on the process flow sheet, Figure 5, and all other materials as well as engineering and field labor involved to create an operable process unit.

An economic evaluation of the process is given in Table 5 on the basis of the aforementioned installa-

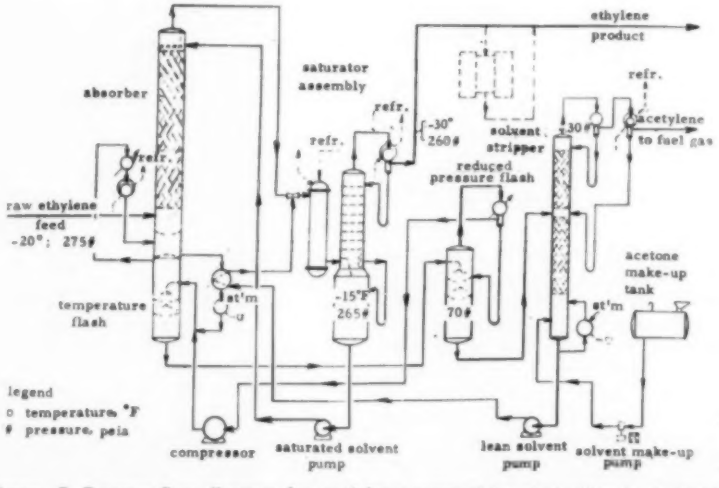


Figure 5. Process flow diagram for acetylene removal by absorption in acetone.

tion cost and the utilities requirements given in Table 4. The acetylene stream is considered as having only fuel value. It contains some ethylene amounting to approximately 0.3 per cent of the ethylene produced which is comparable to the average ethylene loss occurring in a hydrogenation process operating on the raw pyrolysis gas stream. Therefore, no allowance has been made for any product losses. Numerous applications which have been studied by the author and which have involved ethylene production capacities in the range of 75,000 to 250,000 lb. per stream day, have shown that solvent extraction of acetylene adds 0.17 to 0.11 cents per pound, respectively, to the production cost of the ethylene, when determined as illustrated on Table 5.

If acetylene is present in greater quantities in the raw ethylene stream, its recovery as a product may be warranted. The process shown in Figure 5 requires only minor modifications for this purpose and offers the possibility of producing acetylene at a comparatively low cost. Stanton has given in a recent publication(*19*) the conditions, i.e., plant capacity and acetylene concentration, at which the recovery of acetylene by solvent extraction can profitably be undertaken. His study is based on a comparison of catalytic hydrogenation and solvent extraction, both processes applied to the concentrated ethylene product stream. Extractive agents of higher solvent power than acetone, such as dimethyl formamide which has also a low freezing point, may be used advantageously when the recovery of a high purity acetylene by-product is attempted. When merely removing acetylene as an impurity, the solvent circulation required at low temperature is already so small that it is barely sufficient for completely wetting the packing in the absorber. Therefore, it seems that a more powerful and costly solvent would have no operating or economic advantage in the process described in this paper.

In conclusion, it may be stated that acetylene removal by extraction with acetone at low temperature represents an economical process and its application in comparison with catalytic hydrogenation of acetylenic impurity should be investigated in the planning stage of an ethylene production project. Selective absorption may also be applied to a propylene product for the removal of methylacetylene and propadiene. If carbon dioxide, which is usually present in the C_2 fraction, is also to be removed, then acetone may not be the proper solvent to use, as its selectivity between CO_2 and C_2H_2 is rather small.

ACKNOWLEDGMENT

The author is indebted to his associate, William C. Behrmann, for his assistance in the data correlation and in editing the final manuscript of this paper.

Table 5. Plant operating cost.

Acetylene Removal by Acetone
(Ethylene Production: 100,000 lb./day)

Direct Operating Cost				
(a) Utilities (Quantities and Cost per Stream Day)				
Low press. Steam	52,000 lb.	; 0.30/M lb.		$15.60
Electricity	975 kwh.	; 0.08/kwh.		3.80
Cooling Water	90,000 gal.	; 2.00/M gal.		1.80
Fuel Gas	21,600 M Btu.	; 0.25/MM Btu.		5.40
				26.60
(b) Solvent Make-up	3 gal.	; 0.85/gal.		2.55
Misc. Supplies				0.85
Subtotal ;		per Stream Day		$30.00
" ;		$/year	9,990.00	
		$/year		
(c) Labor: Operating		6,500.00		
Maintenance		3,100.00	9,600.00	
(d) Maintenance Materials			3,000.00	
Indirect Operating Cost				
(a) Overhead; 60 % of Labor			5,760.00	
(b) Taxes, Insur., etc.; 2.5% of Investment			4,375.00	
(c) Depreciation; 10% " "			17,500.00	
(d) Interest on unamortized Investment			4,810.00	
Annual Operating Cost			55,035.00	
" " " , ¢/lb. of Ethylene			0.165	

NOTATION

H	= Henry's Law constant	atm.
H_s	= Heat of absorption	Btu./lb.
K	= Equilibrium ratio	$K = \frac{y}{x}$
M	= Molecular weight	lb./mol
N	= Number of mols	
NTP	= Normal Temperature & Pressure (32°F & 1 atm. abs.)	
P	= Vapor pressure of pure compound	atm.
R	= Gas constant	1.9872
T	= Absolute temperature	°R
X	= Molal ratio; Solute/Solvent	
p	= Partial pressure	atm.
t	= Temperature	°F
x	= Mol fraction in liquid	
y	= Mol fraction in vapor	
α	= Bunsen Solubility Coefficient Vol. of gas (NTP) dissolved in 1 Vol. of Solvent (measured at t & π)	
λ	= Ostwald Solubility Coefficient Vol. of gas dissolved in 1 Vol. of Solvent; both measured at t & π	
γ	= Activity Coefficient	$\gamma = \frac{\pi y}{P_s x}$
π	= System Pressure	atm. abs.
ρ	= Density	lb./cu. ft.

Subscripts

s	= refers to solvent
i	= refers to gas component of highest solubility
1,2. . .n	= refers to other components in gas
l	= refers to liquid phase
v	= refers to vapor phase

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Alkylating aromatic hydrocarbons

Data now available shows flexibility in brand new process. Benzene, toluene, xylene can be successfully alkylated with olefins with conversions held at 100% despite wide range of olefin concentration in process gas.

THE Alkar* process is a petrochemical process developed by Universal Oil Products Company for the economical manufacture of a wide variety of alkylated aromatics.

The process embodies a number of unique features. It uses an entirely new fixed bed catalyst system, can use low olefin content gas streams which are otherwise only of fuel value, and obtains complete conversion of olefins to alkyl aromatics. It produces petrochemical products of superpurity. It obtains yields of alkyl aromatics which may be essentially quantitative, both with respect to the olefin and to the aromatic. Because the process employs moderate operating conditions and involves no corrosion problems, capital investments are moderate. It will give profitable operations, even for relatively small units.

Utilizing this process, benzene can be alkylated with olefins ranging from ethylene, propylene and butylenes, up through higher molecular weight olefins. Toluene, xylenes, and other aromatics can be similarly alkylated.

The process can be controlled to yield essentially only monoalkylated aromatics. Alternately, excellent yields of particular polyalkylated aromatics, such as dialkylated benzenes, can be obtained.

Ethylbenzene

Ethylbenzene can be produced by the Alkar process either from the ethylene streams ordinarily used for chemical conversions, or from very dilute ethylene streams. In the past, such streams have, of necessity, been diverted to fuel, or have required expensive concentration of ethylene prior to use. Pilot plant operations by UOP have, over extended periods of time, successfully utilized feed gases containing less than 10% ethylene. During these operations, yields of ethylbenzene were 100%, based on both the benzene consumed and on the ethylene fed. This high yield has been obtained over a relatively wide range of benzene-to-ethylene ratios when employing recycle of the polyethylbenzenes.

The process involves reactions of ethylene with benzene as illustrated by Figure 1. Although ethylbenzene is ordinarily the major product, polyethylbenzenes are simultaneously produced, the extent of such polyalkylation being greater at low benzene-to-ethylene ratios.

The process catalyst system is also effective in promoting transalkylation of polyalkylated aromatics. This type of reaction is illustrated in Figure 2, which shows that polyethylbenzenes will react with benzene to form successively less alkylated aromatics down to monoethylbenzene.

In pilot plant runs, full recycle operation was performed; fresh feed benzene and dilute ethylene gas were introduced, and only ethylbenzene and inert gas were withdrawn. The pilot plant recycled all excess benzene leaving the reaction zone, and all material boiling above ethylbenzene. The composition of these recycle streams and their flow rates reached a steady state.

The ability to get a quantitative yield with complete polyalkylate recycle even at low benzene-to-ethylene ratios, demonstrates the ability of the process to secure complete transalkylation. Only by such full recycle experiments can one be certain that transalkylation is complete.

The conversion of the ethylene is complete and the ability of the process to give 100% reaction of ethylene, even when it is present at less than 5% in the feed gases, is outstanding in the petrochemical field. This process is not limited, however, to low olefin content feed gas. It also gives complete conversion from 95% (commercially pure) ethylene streams. With high purity ethylene feed, the yields are also quantitative. If such high purity gases are available, considerable economy in the plant operation results from the simplification of the feed gas treating section and of equipment handling tail gas.

Product purity. The reactions in the process are extremely clean cut, as evidenced both by the high purity of products and by the quantitative accounting for feed reactants in the

Table 1. Alkar ethylbenzene compared with API reference standard.

	API REF. (212x – 25)	ALKAR PRODUCT
C_9 Aromatics	None	None
Paraffins	0.008 to 0.015 mol %	0.003 to 0.008 mol %
Cyclo-Paraffins }	0.004 to 0.008 mol %	0.002 to 0.006 mol %
Olefins }		
Bromine No. (Bromine Index Method)		(0.001)
Refractive Index at 20°C		1.4957 *
Specific Gravity 60°F		0.8717 **

* *API Project 44 gives 1.4959, Egloff 1.4960*
** *API Project 44 gives 0.8718*

* Trademark

alkylaromatic products. Purity of ethylbenzene product is excellent from both high and low ethylene content feed gases.

High sensitivity mass spectrometer analyses of the ethylbenzenes produced demonstrate the product to be of extremely high purity. The sample, analyzed and reported in Table 1, was prepared under full recycle operation with stoichiometric yield. This product was found to contain less impurities than API ethylbenzene reference standard. The reference standard had a 99.95 mol-% minimum purity as determined by freezing point.

Other products

Today the polyethylated benzenes are not of such commercial volume as the monoalkylated material, but are interesting and important intermediates. While the principal interest has been to develop a process for ethylbenzene manufacture, due to its very large and growing demand, it is of real interest to note that the process permits the manufacture, in excellent yields, of particular polyalkylated aromatics such as the mixed isomers of diethylbenzenes. This may be accomplished largely by recycling all undesired alkyl aromatics to the reaction zone, coupled with appropriate modifications of reaction conditions. Typical isomer distributions obtained from such selective operations to make diethylbenzenes and triethylbenzenes are shown in Table 2.

Table 2. Typical isomer distributions for polyethylbenzenes.

Diethylbenzenes		Triethylbenzenes	
1,2	26%	1,2,3	3%
1,3	49	1,2,4	35
1,4	25	1,3,5	62

An interesting compound which has been produced by the operation is hexaethylbenzene, a white crystalline compound. The crude product melted at 257°F, and after recrystallization, melted at 260-262°F. (literature value 262°F). A mixed melting point with pure hexamethylbenzene confirmed the composition.

The propylation of benzene with the process catalyst system proceeds in a manner analogous to ethylation. Once-through operations yield principally cumene (isopropylbenzene), and by appropriate choice of recycle 100% cumene yield may be obtained. Alternatively diisopropylbenzenes rich in the para isomer may be produced. It is well known that propylene has a tendency to form polymers over many catalysts, hence it is of importance that the catalyzed propylation of benzene can be controlled to yield cumene product of extremely low olefin content. The data of Table 3 indicate the characteristic properties of cumene produced this way.

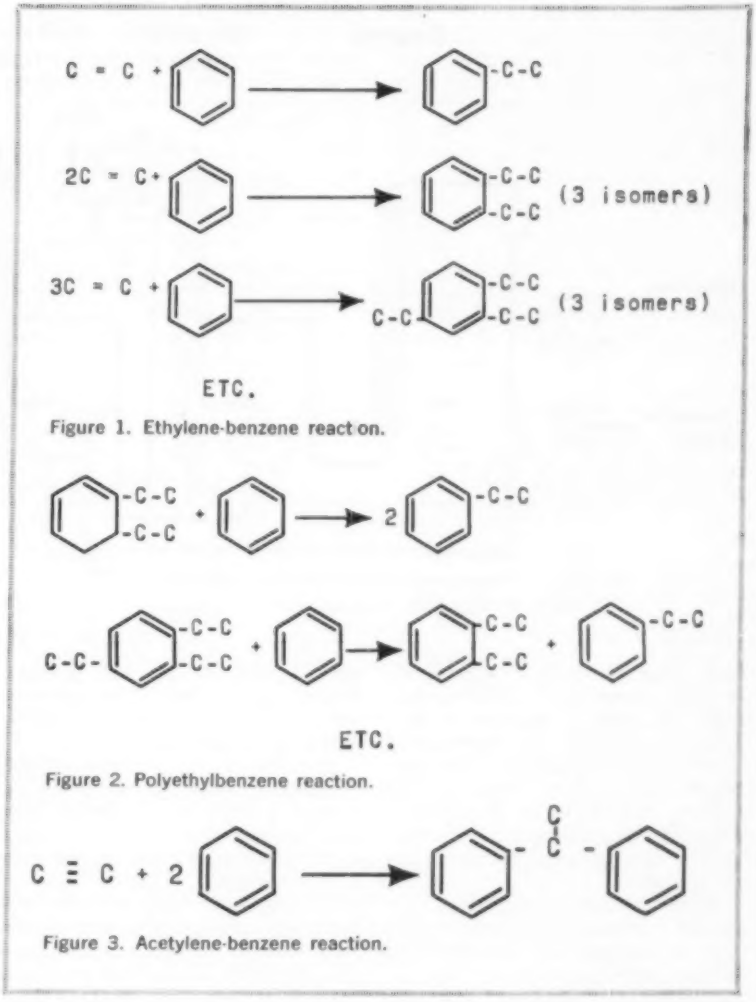

Figure 1. Ethylene-benzene reaction.

Figure 2. Polyethylbenzene reaction.

Figure 3. Acetylene-benzene reaction.

In considering the manufacture of polypropylated benzenes, it has been found that the reaction conditions have an important effect on isomer distribution. Although an exhaustive study has not yet been completed, the data of Table 4 indicate the ranges in composition of the diisopropylbenzene isomers which have so far been obtained.

Gases containing wide ranges of propylene content may be successfully processed.

Studies of dilute olefin-containing feed gases have included mixtures of ethylene and propylene, the two olefins most commonly encountered in such low cost gases. Extensive pilot plant operations, similar to those using dilute ethylene, have demonstrated that both ethylbenzene and cumene of high purity can be made in substantially quantitative yields. These runs indicate that transalkylation proceeds completely, both for polypropylated benzenes, and even for "cross-alkylated" materials containing both ethyl and isopropyl alkyl groups.

If significant quantities of butylenes were included, along with ethylene and propylene, butylbenzenes of high purity could be produced and separated as a third co-product. Due to the relatively small volatility difference between diethylbenzenes and butylbenzenes this appears uneconomical, and separation of the feed olefins with parallel alkylations may be preferable.

A variety of other hydrocarbons

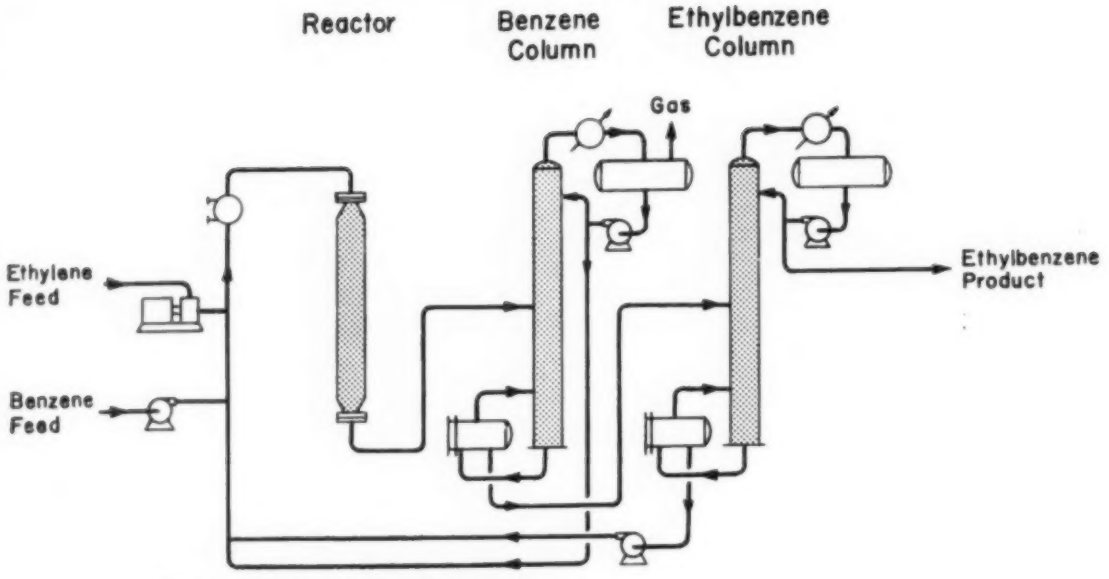

Figure 4. Simplified Alkar process flow sheet.

have been tested in experiments. Acetylene reacts in a clean manner with two moles of benzene to give 1,1-diphenylethane, an intermediate which may be of interest. This reaction is illustrated in Figure 3. The reaction appears to be quantitative, even when the acetylene is at a fraction of one percent concentration in the feed gas.

When alkylating benzene with normal butylenes using many catalyst systems, mixtures of secondary and tertiary butylbenzenes are the expected result. However, with this catalyst system, normal butylenes may be reacted with benzene to give essentially pure secondary butylbenzene.

Experiments with normally liquid olefins indicate that these can be successfully alkylated with aromatics. Benzene has been alkylated with propylene tetramer to give dodecylbenzene (detergent alkylate), and also with a mixture of higher olefins boiling up to the 24 carbon-atom range to make very high boiling alkylbenzenes.

Mixed aromatics. Additional flexibility of the technique is demonstrated by its application to the reaction of olefins with the mixed aromatics contained in such refinery streams as reformates, the aromatic rich gasoline products from catalytic reforming of naphthas.

In Table 5 the reactions of the aromatics contained in a typical reformate fraction are illustrated. This fraction contained about 50% total aromatics, which, as can be seen, are largely toluene and xylenes, with lesser amounts of benzene and ethylbenzene also present. These aromatics were reacted with ethylene and propylene contained in a dilute gas of approximately 10% total olefin content. The ethylene was about 2½ times the propylene content.

Complete reaction of the olefins occurred, showing that the non-aromatic liquids did not suppress the desired alkylation reactions.

The results of such operations as in Table 5 are perhaps more applicable to petroleum refining applications than to petrochemical manufacture because a complex mixture of products is made. The total liquid feed in this example had octane numbers of 84.9 F-1 clear, and 96.3 F-1 with 3-ml. tetraethyl lead. The product increased in octane numbers to 86.8 F-1 clear, and 97.2 F-1 leaded.

Table 3. Analysis of cumene produced.

Boiling Range	Less than 2°F
Cumene, % (Infrared Analysis)	100.0
Specific Gravity at 60°F.	0.8666*
Bromine Number (Bromine Index Method)	0.005
Refractive Index at 20°C.	1.4913**

* *API Project 44 gives 0.8664*
** *API Project 44 gives 1.4915, Egloff 1.4915*

Table 4. Isomer distributions of disopropylbenzenes.

Ortho	4 to 15%
Meta	27 to 62%
Para	61 to 32%

The volumetric yield of product was 104.7% of the liquid feed.

Process flow. While this has covered a wide variety of process applications, the basic flow scheme for many is remarkably similar, for in almost all cases excess feed aromatic is recycled to the reaction zone together with the undesired alkylated products. It would then seem possible to build a plant which could, with only modest alterations, be adapted to a wide variety of alkylations.

Figure 4 shows an Alkar plant as arranged to produce ethylbenzene from 95% ethylene. Feed gas is compressed, if required, and passes to the reactor section together with fresh and recycle benzene. After heating with either steam or hot oil, the benzene and olefin pass into the reactor section.

The products of reaction, which consist of alkylated aromatics, excess benzene, and any inert part of the feed gas, go to the fractionation section.

In this example, the fractionation equipment consists of only two columns. The first column separates excess benzene for recycle to the reactor. In the second column super-purity ethylbenzene is recovered as the over-

head product. The bottoms of the ethylbenzene column contain the polyalkylated benzenes which are recharged to the reactor.

Normally with high purity ethylene, benzene recovery from the vented receiver gas is uneconomical, but the polyalkyls may be used as absorption oil to recover benzene vapors. The rich absorption oil would then be charged to the reactor system.

When processing dilute gas streams, or mixtures of olefin feeds, this plant must be elaborated somewhat by addition of off-gas handling equipment or additional product fractionators.

Economics. It is difficult to generalize on the subject of economics considering the wide range of alkylations to which the process can be applied. In addition, even for a specific application there are many factors which are local in character, which may vary from one company to another, and which also can vary with locale in the case of multiplant corporations.

For purposes of illustration economic figures are derived for the case of a chemical manufacturer producing ethylbenzene from purchased 98% ethylene and from purchased nitration-grade benzene. The plant required for such manufacture corresponds to the flow diagram of Figure 4, and represents a battery-limits investment of some $700,000.

In Table 6 are the yield structures appropriate to this situation. Conversion efficiency is essentially 100% on both ethylene and benzene feed, resulting in a production rate of 100,000 pounds of ethylbenzene a day. Allowance has been made for withdrawal of 1% of the benzene feed in order to insure removal of the very minor quantities of non-aromatics introduced even with nitration-grade benzene.

The operating cost elements for this plant are outlined in Table 7, and total to only 1.1 cents a pound of ethylbenzene product.

The manufacturing costs to produce ethylbenzene by the new process, excluding profit and sales expense, are shown in Table 8. Benzene has been priced at the current posting of 31 cents a gallon, and is the largest element of the total manufacturing cost, being equal to 3.1 cents a pound of ethylbenzene. The ethylene-ethane feed has been priced at 5 cents a pound, equivalent to 1.3 cents a pound of ethylbenzene. On adding the operating costs to the raw material costs, a total cost of manufacturing ethylbenzene, before royalty charge, of 5.5 cents a pound is obtained. With styrene quoted at 12.6 cents a pound, the differential offers an attractive margin to cover the costs involved in ethylbenzene dehydrogenation, other miscellaneous expenses, and also to provide a reasonable manufacturing profit.

Previous papers (*1*) on the process have presented the economics of operations using dilute gas feeds. With the olefin available at fuel value, an even lower total manufacturing cost results.

Table 5. Operation with mixed olefins and mixed aromatics.

	Mols	Percent Disappearance
Aromatics Feed		
Benzene	11.0	
Toluene	42.6	
Xylenes	33.6	
Ethylbenzene	12.8	
	100.0	
Olefin Feed		
Ethylene	25.3	
Propylene	9.3	
	34.6	
Products		
Benzene	9.6	12
Toluene	32.7	23
Xylenes	24.1	29
Ethylbenzenes	6.2	52
Ethyltoluenes	5.6	
Propyltoluenes	3.5	
Ethylxylenes	12.7	
Higher Aromatics	5.6	
	100.0	

Table 6. Process economics—yields.

	SCF/Day	Barrels Per Day	Pounds Per Day
Feeds			
Benzene	....	240	74,300
Ethylene	356,000	....	26,320
Ethane	6,300	....	500
	362,300		101,120
Products			
Ethane	....	....	500
Ethylbenzene	....	328	100,000
Benzene Purge Stream*	....	2	620
			101,120

* *Allowance to permit removal of non-aromatics introduced with feed benzene.*

Table 7. Process economics—investment and operating costs.

Erected Cost of Alkar Plant $700,000

Operating Costs	Dollars Per Day	Cents Per Lb. E.B.
Labor, 1½ Men/Shift @ $3/Hr.	108	
Supervision and Overheads	108	
Laboratory Expense	50	
Utilities	155	
Catalyst and Chemicals	253	
Maintenance Allowance[1]	64	
Taxes and Insurance Allowance[2]	53	
Amortization of Plant Investment[3]	210	
Interest on Investment[4]	64	
Total Operating Costs	1,067	1.07

[1] *Estimated at 3% annual of process investment.*
[2] *Estimated at 2½% annual of process investment.*
[3] *Estimated at 10% annual of process investment.*
[4] *Estimated at 3% average, on initial process investment.*

Table 8. Process economics—manufacturing costs.

	Dollars Per Day	Cents Per Lb. E.B.
Feed Stocks		
Benzene—240 BPSD @ 31¢/Gal.	3,120	3.12
Ethylene-Ethane—26,820 lbs. @ 5¢/Lb.	1,340	1.34
Total Feed Stocks	4,460	4.46
Operating Costs	1,067	1.07
Total Manufacturing Cost	5,527	5.53

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Hydrogen sulfide desorption from NaCl brine

Design of a commercial unit was based on mass transfer data developed from experimental equipment. Sulfide removal was satisfactorily accomplished in scale-up.

In a study centered around the removal of dissolved sulfides from brine, preliminary experiments indicated that most could be removed by bubbling air through the brine. This was done most effectively in a countercurrent contacting device.

Unfortunately, a search of the literature failed to yield any information that could be used for the design of an operating unit. An experimental device was therefore set up to determine the mass transfer coefficient for desorption of sulfides from sodium chloride brine.

The overall liquid phase mass transfer coefficient, K_La, was determined. K_La depends essentially on the liquid rate. At high liquid rates, the gas rate becomes more significant. This information is shown in the graph, Figure 3. The curve for CO_2 is shown for comparison.

Experimental

An eight inch diameter column packed with 14.5 feet of one inch Raschig rings was used. Brine and air flows were measured with rotameters. Inlet and outlet brine streams were analyzed for both free H_2S and total sulfides. All results are based on total sulfides because this analysis is more accurate, and "free H_2S" depends on pH.

The initial sulfide content of the brine expressed as H_2S was 0.05 to 0.20 grams per liter. The brine solution is near saturation with respect to NaCl, and it contains magnesium and calcium as impurities.

The raw brine had an average temperature of 98°F in these experiments. The pH was 6.8.

Effect of pH

The pH of a brine determines, apparently, how the sulfides exist in the brine. In acidic brines the sulfides exist mainly as free H_2S. The brine used in this study had a pH of 6.8 before sulfide removal. The pH rose slightly after removal. Although the exit air was not analyzed for H_2S, it was assumed that sulfides were removed as H_2S since this was obviously contained in the exit air. Several analyses of the brine showed no increase in the sulfate content. There was no evidence that the rate of hydrolysis was involved in the experiments. Many of the experiments showed a total sulfide removal of 85 to 95%. At this level of removal hydrolysis had to occur.

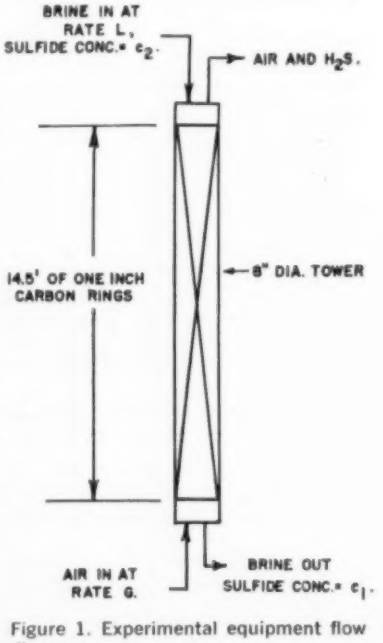


Figure 1. Experimental equipment flow diagram.

Assumptions

1. It was assumed that the sulfides were all present as H_2S. This is not true but implies that as the free H_2S is removed, hydrolysis can proceed at a rate that is not controlling.
2. The main resistance is in the liquid film. This assumption should be true as H_2S is a slightly soluble gas. Experiments justified this assumption.
3. It was assumed that the solubility of H_2S followed Henry's Law, and that the data for H_2S in 3*N* NaCl could be used. This assumption is necessary in order to calculate the driving force or concentration difference at the top of the tower. The solubility in water when compared to 3*N* NaCl is of the same order, the solubility being only slightly higher in water. It was felt justifiable, therefore, to assume that there would not be an appreciable solubility change in going from 3*N* NaCl to approximately 5*N* NaCl.

Results

The value of K_La as a function of the brine rate, L, is shown in the curve, Figure 3. K_La was calculated using the equation, $N_Aa = K_La\ (c\text{-}c_e)$ av. The term $(c\text{–}c_e)$ av. is the log mean average of the driving forces at the top and bottom of the tower in terms of H_2S concentration in the liquid. Henry's Law was used to determine the driving force at the tower top $(c\text{-}c_{e2})$. c_2 was determined by laboratory analysis. The calculation of c_{e2} involved a material balance to determine the partial pressure of H_2S in the leaving air and the subsequent use of Henry's Law to evaluate the equilibrium concentration in the liquid.

The driving force at the bottom of the tower $(c_1\text{-}c_{e1})$ reduces to c_1 since p_1 is zero—no H_2S in the entering air.

The plot of K_La (indicates that K_La) is essentially a function of the liquid rate. As the liquid rate, L, is increased, the air rates does have some effect on K_La.

Shown on the same graph is the currve for CO_2 (*1*) taken from the literature. The slope of this curve is quite similar.

Conclusions

The values of K_La can be used to calculate removal of sulfides from brine under similar conditions reported here. Values of K_La for free H_2S were calculated in some cases and the line is parallel to the total sulfide line and always higher. Hence, the values for total sulfides should be conservative for H_2S alone.

Application

A large scale-up was made for commercial operation using the K_La values reported. The commercial installation came reasonably close to removing the fraction of sulfides for which it was designed. Actually, the slight error in the scale-up may have been due to an improper allowance for change in packing size, or in neglecting the wall effect, the brine distributor, and the gas distribution at the bottom. All of these would tend to give proportionately higher rates of removal in the experimental tower. It is recommended, therefore, that the values of K_La reported be taken as somewhat high when applied to sulfides in larger equipment.

When using packing other than one inch rings, some allowances should be made. The application of K_La data for one type and size of packing to other types and sizes has been reported in recent literature (*2*).

Figure 1 is a schematic sketch of the equipment used.

Figure 2 is a plot of % sulfides removed versus the brine rate. From this it can be concluded that the removal of sulfides is mainly dependent on the brine rate.

Figure 3 is a plot of K_La as a function of L. Although there is some indication that K_La increases as G increases, only one curve has been drawn. The points for various gas rates are shown. It is only at high liquid rates that the data show considerable spread. At high liquid and gas rates there was some evidence that the flood point of the tower was neared. It was felt it was not justified to show any dependence of K_La on G with these limited data.

Calculation of K_La

Henry's Law, $H = p/x$ was used to determine the value of c_e. At a given air rate, G, the actual transfer of H_2S from the brine to the air can be calculated. This is done by a material balance, $(c_2\text{-}c_1)$ (cu. ft. brine /unit time) = lb. mol H_2S transferred/unit time = $(c_{G2}\text{-}c_{G1})$ (cu. ft. air/unit time).

It is obvious that c_{G1} is always zero and c_{G2} must, therefore, represent all the H_2S removed from the liquid. Having thus determined the H_2S in the leaving air stream, this can be converted to p_2, and then x_e calculated from Henry's Law constant. Henry's Law constant is available for water and can be calculated for 3*N* NaCl brine from other data (*3*).

A sample calculation.

Run No. 1

Air Rate = 20 cu. ft./min.

Brine Rate = 0.242 cu. ft./min.

Sulfide Analysis, Brine in = 0.085 gm./l.

Sulfide Analysis, Brine out = 0.010 gm./l.

Tower Area (8″ Sch. 40 Pipe) = 0.318 sq. ft.

L = 3,380 lb./hr., sq. ft.

G = 274 lb./hr., sq. ft.

Conversion factor, gm./l. to lb. mole/cu. ft. = 1.9×10^{-3}

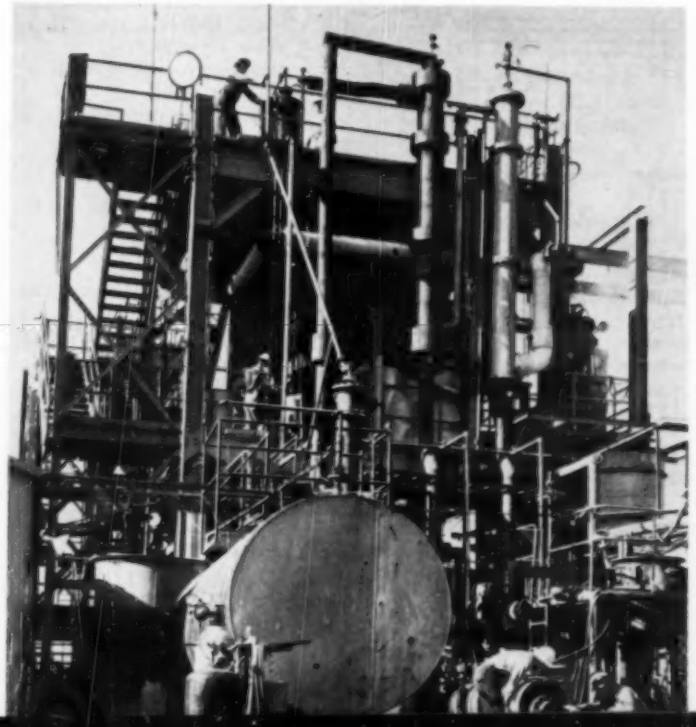
$c_2 = (0.085)\ (1.9 \times 10^{-3}) = 161 \times 10^{-6}$ lb. mole/cu. ft.

$c_1 = (0.010)\ (1.9 \times 10^{-3}) = 19 \times 10^{-6}$ lb. mole/cu. ft.

Solubility of H_2S in 3*N* NaCl at 1 atm. of $H_2S = 3.3 \times 10^{-3}$ lb. mole/cu. ft. (*4*)

Moles H_2S desorbed = (0.075gm/1) (1.9×10^{-3}) (0.242 cu. ft./min.) (60) $= 2 \times 10^{-3}$ lb. mole/hr.

Since the volume of H_2S in the



Pertinent data were obtained in units such as this large pilot plant unit of Columbia-Southern Chemical Corp., New Martinsville, W. Va.

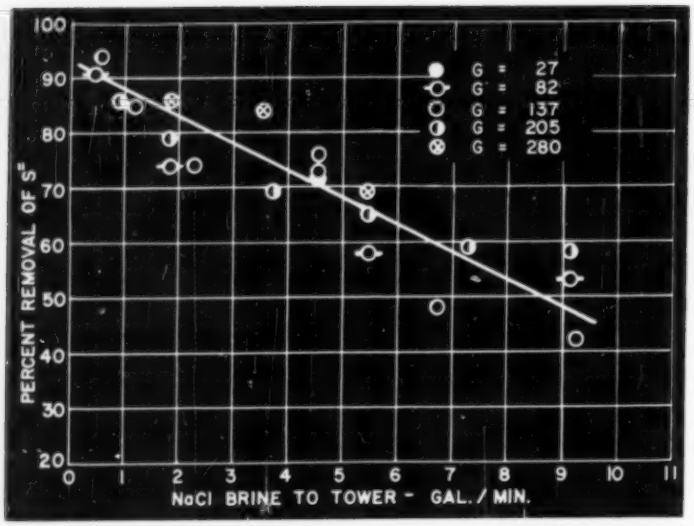


Figure 2. Plot of original data showing the variation in sulfide removal with brine rate.

vapor phase is negligible,

$$p_2 = \frac{\text{moles } H_2S \text{ desorbed/hr.}}{\text{moles air fed/hr.}} = \frac{2 \times 10^{-3}}{2.84} = 0.706 \times 10^{-3} \text{ atm.}$$

Applying Henry's Law, knowing the solubility of H_2S and its partial pressure; $3.3 \times 10^{-3}\ p_2 = c_{e2}$

$(3.3 \times 10^{-3})\ (.706 \times 10^{-3}) - c_{e2} = 2.2 \times 10^{-6}$ lb. mole/cu. ft.

For the incoming brine, $c_{e1} = 0$

Driving force at the top of the tower $= (c_2 - c_{e2}) = (161 - 2.2)\ 10^{-6} = 158.8 \times 10^{-6}$ lb. mole/cu. ft.

Driving force at the bottom of the tower $= (c_1 - c_{e1}) = (19 - 0)\ 10^{-6} = 19 \times 10^{-6}$ lb. mole/cu. ft.

average driving force $= (c - c_e)$ avg.

$$\frac{(158.8 - 19)\ 10^{-6}}{2.3 \log \left(\frac{158 \times 10^{-6}}{19 \times 10^{-6}} \right)} = (c - c_e) \text{ avg.}$$

$= 65.9 \times 10^{-6}$ lb. mole/cu. ft.

Moles H_2S desorbed per hour per volume of packing $=$

$$N_A a = \frac{2 \times 10^{-3}}{4.62} \text{ lb. mole/hr.,}$$

cu. ft. where 4.62 cu. ft. is the tower volume occupied by the packed section. Since

$N_A a = K_L a\ (c - c_e)$ avg.

$$K_L a = \frac{2 \times 10^{-3}}{(4.62)\ (65.9 \times 10^{-6})}$$

$K_L a = 6.6$ lb. moles/[hr., sq. ft. (lb. moles/cu. ft.)]

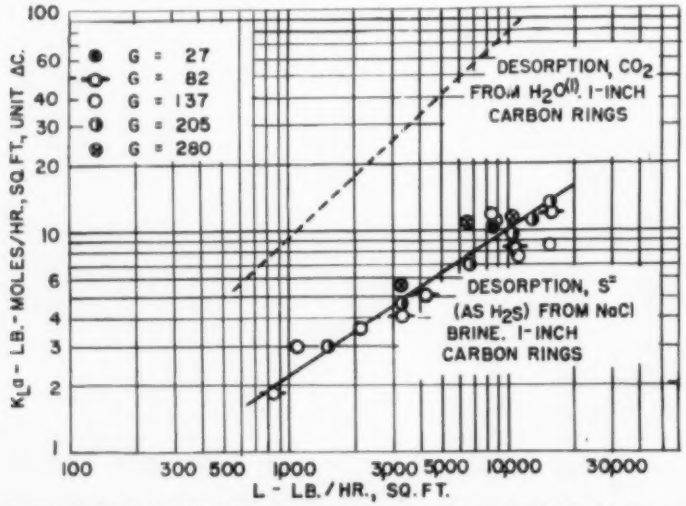


Figure 3. Plot showing the variation of the experimentally determined mass transfer coefficient with brine mass velocity.

Knowing $K_L a$, the height of packing required to desorb a specified quantity of H_2S from NaCl brine was calculated from the equation;

$N_A a\ (V) = K_L a\ (c - c_e)$ avg. (Ah)

The quantity of H_2S to be desorbed $= N_A a\ (V)$ lb. moles/hr.

Acknowledgement is made to Dr. Joseph H. Koffolt at Ohio State University and to Dr. E. R. Gilliland at Massachusetts Institute of Technology who kindly criticized the article and encouraged its publication.

Thanks is given to Columbia-Southern Chemical Corporation for permission to publish the article, and to their personnel who assisted in many ways. I wish particularly to thank A. P. Muren, Development Engineer, for the preparation of the curves and for checking the calculations.

NOTATION

- A = Tower cross-sectional area, sq. ft.
- a = Area of interphase contact, sq. ft./cu. ft.
- c = H_2S concentration in the brine, lb. mole/cu. ft.
- c_e = H_2S concentration in the brine corresponding to equilibrium with the gas, lb. moles/cu. ft.
- c_{ti} = H_2S concentration in the gas, lb. moles/cu. ft.
- G = Mass velocity of air to tower, lb./(hr.) (sq. ft. of tower cross section).
- H = Henry's Law constant, atm.
- h = Height of packed section of tower, ft.
- $K_L a$ = Liquid film mass transfer coefficient on a volume basis, lb. moles/(hr.), (sq. ft.), (lb. moles/cu. ft.).
- L = Brine rate on a solute-free basis, lb./(hr.), (sq. ft. of tower cross section).
- N_A = H_2S desorption rate, lb. mol./(hr.) (sq. ft.).
- p = H_2S partial pressure in gas phase, atm.
- V = Volume of desorption section in tower, cu. ft.
- x = Mole fraction of solute in the liquid.

SUBSCRIPTS

1. Bottom of tower (brine outlet, air inlet).
2. Top of tower (brine inlet, air outlet).

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Compacting Granular Solids

Use this mechanism for designing compacting equipment and eliminate need for building prototype machines.

THE UNIT OPERATION of size reduction is widely practiced in industry, and a substantial amount of theoretical and experimental work has been done in this area. By contrast, the logical complement to this operation, size enlargement, is rather restricted in usage and no correlations useful for design of equipment exist.

The classic method of mechanical size enlargement is pelletizing or tabletting. This process is restricted to relatively expensive materials due to the high cost and low capacity of the equipment. The development of continuous compacting machines has eliminated this restriction. These machines consist basically of a pair of horizontal cast iron rolls, 18 or 24 in. diameter and 16 to 24 in. effective length rotating face-to-face and held together by hydraulically actuated pistons acting on the bearings. Such a machine is illustrated in Figure 1.

The fine material to be compacted is fed continuously into the nip of the rolls from above. This material is drawn between the rotating rolls where very high pressures are developed which compact and agglutinate the feed so that a continuous sheet of product is ejected from the bottom of the rolls. The void content of the product may approach zero and the sheet thickness may vary from ¼ in. down to 0.020 in.

The compacted sheet may be subsequently granulated and screened to produce any mesh range desired. Figure 2 illustrates muriate of potash before compaction, after ejection from the compactor and after granulation.

The compaction process, as described above, is now applied to a wide variety of products, including ammonium sulfate and rock salt fines. At Solvay, compactors are used for the conversion of fine sodium nitrite to non-caking flakes and for production of very coarse salt from precipitated sodium chloride which is used in place of rock salt for ice control purposes.

In general, the compaction process is applicable to the conversion of attrition products and dust to coarse, salable product and to the conversion of a naturally fine product into a coarser product. This is frequently desirable in order to eliminate caking, enhance flow properties, eliminate dust formation, increase density, or affect solution rates.

A search of the literature showed that no theoretical analysis of the compaction process had been attempted, nor were there any useful design correlations available. Hence, an attempt was made to arrive at a reasonable mechanism for compaction between rolls and to develop from this mechanism and the results of an experimental investigation equations which would allow design of compacting equipment without recourse to the use of prototype machines.

Such a mechanism and the derived equations are presented in this paper. The equations are checked by comparing theoretical with observed operating conditions from actual equipment and the agreement is found to be excellent.

Due to the different nature of the process, the theoretical equations developed for the rolling of steel billets are not applicable.

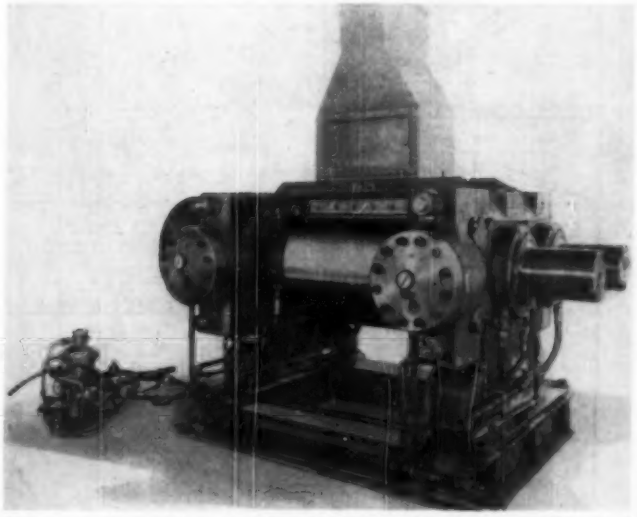

Figure 1. Compacting machine. (Courtesy Allis-Chalmers Mfg. Co.)

Mechanism of compaction

The simple mechanism which is postulated for compaction of granular solids between rolls is illustrated by Figure 3. The free-flowing feed enters the nip of the rolls from above and is carried between the rolls by their rotation. Above the angle θ_1, called

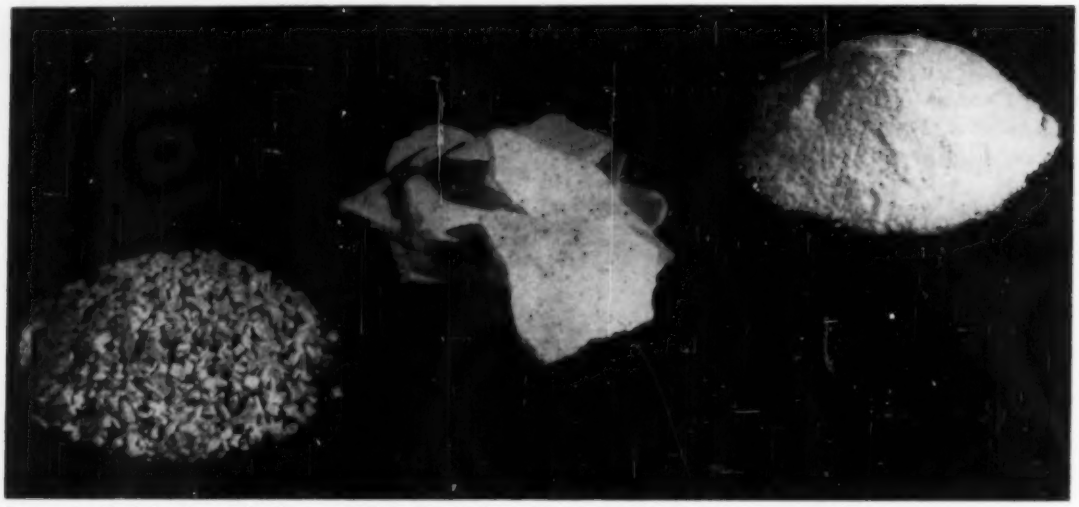

Figure 2. Muriate of potash. (L. to r.) after granulation; after compaction; before compaction.

the angle of nip, the feed remains free-flowing and is in turbulent motion. At the angle of nip, the material loses its free-flowing character and below this angle it is assumed that a horizontal increment taken through the feed remains horizontal throughout its passage between the rolls and that there is no relative motion between this increment and the moving roll faces. It is also assumed, for the moment, that the decrease in width of the element is due entirely to increasing density.

The extent of compaction may be measured by the void fraction included within the bulk of the material undergoing compaction. Void fraction is given by:

$$V_i = \frac{\rho_0 - \rho_i}{\rho_0} \qquad (1)$$

On the basis of the postulated mechanism, the following equation may be derived:

$$V_i = 1 - \frac{\rho_1[D_R(1-\cos\theta_1)+D_S]}{\rho_0[D_R(1-\cos\theta_i)+D_S]} \qquad (2)$$

Equation 2 expresses the relationship between the void content of the solid at any angle θ_i below the angle of nip θ_1 and is valid only for $V_i > 0$.

If the postulated mechanism holds, there is a simple relation between the void content of the product and the angle of nip, given by:

$$\cos\theta_1 = 1 + \frac{D_S}{D_R}\left(1 - \frac{1-V_S}{1-V_1}\right) \qquad (3)$$

When the roll diameter (D_R), roll gap (D_S), and void content of the feed at the angle of nip are set, the product void content is a function only of the angle of nip.

The pressure developed on the rolls by the compaction process will be resolved as a horizontal force on the pistons acting on the roll-bearing blocks. This force is given by:

$$F_H = \frac{\pi D_R L}{360}\int_0^{\theta m} P\cos\theta d\theta \qquad (4)$$

In order to integrate this equation, it is only necessary to determine the relation between compaction pressure and void content, since the relation between void content and angle is known, Equation 2, based on the postulated mechanism.

Pressure-void content relation

The relation between compaction pressure and void content of the compacted aggregate is characteristic of the physical nature of the substance involved and the conditions of the feed stock (temperature, granulation, etc.). Experimental determinations of this relation are readily made by applying small increments of pressure to a sample in a closed die and determin-

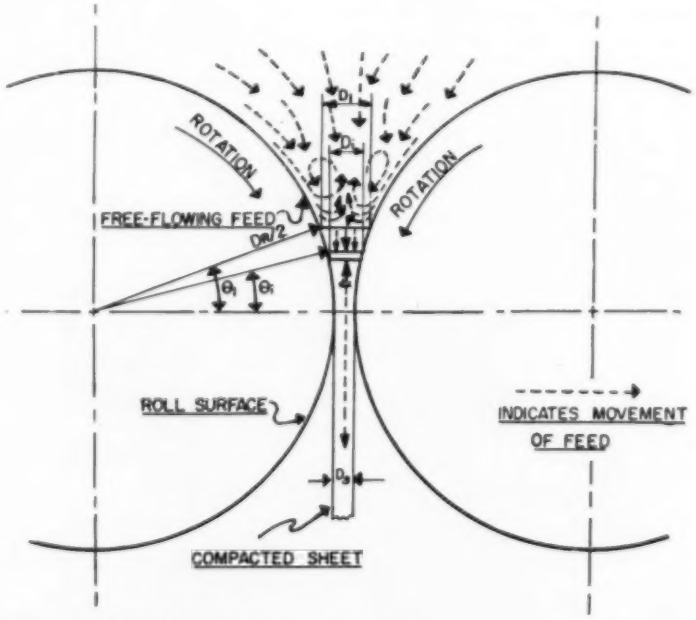

Figure 3. Postulated mechanism of compaction.

ing the void content of the sample at each pressure by noting the position of the piston. Figure 4 illustrates the appearance of a sample of compacted sodium chloride at a series of pressures. Compaction curves of void content versus pressure have been obtained for several substances. When these experimental curves are presented as void content versus the log of the compaction pressure, a characteristic shape is revealed. This is illustrated by Figures 5 through 7.

It is found that these curves represent the sum of three straight lines on the ln P vs. percent voids plot.

$$P = Ce^{-cV_i} + Be^{-bV_i} - Ae^{aV_i} \quad (5)$$

If we refer to the range of void contents dominated by each of these lines as compaction regions—where Region I is from the uncompacted void content to about 25%, Region II from about 25% to about 10%, Region III from about 10% to 0%, and Region IV at 0% voids, then a rational explanation of the shapes of these curves may be postulated.

Region I is the free-flowing region in which decrease in void content occurs by reorientation or packing of the granules composing the feed.

When the minimum void content attainable by packing is approached, the feed becomes cohesive and reduction in void content is accomplished by crushing of the larger particles of the feed aggregate. This occurs in Region II, the compaction region.

As the void content reaches the vicinity of 10% or Region III, plastic deformation of the feed granules becomes important and as the void content approaches zero, increasing compaction pressure induces relatively less

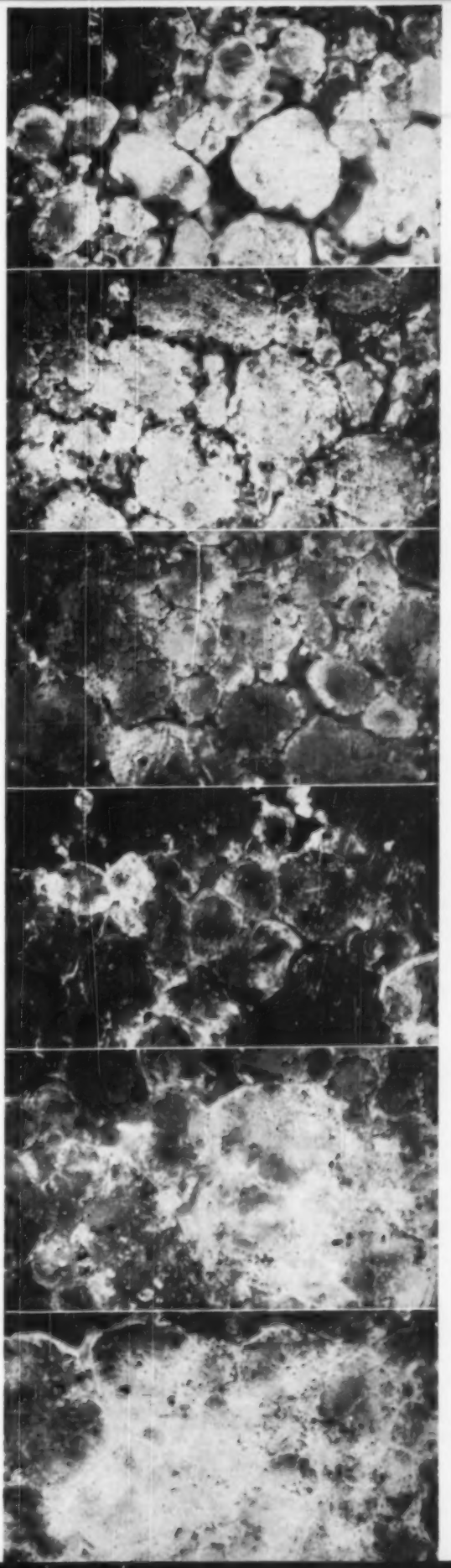

Figure 4. Photomicrographs of compacted sodium chloride(300X). Top to bottom: 8 ksi; 16 ksi; 24 ksi; 32 ksi; 48 ksi; 64 ksi.

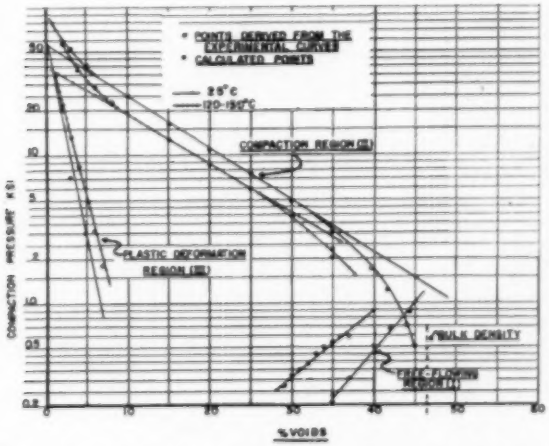

Figure 5. Compaction pressure vs. percent voids for precipitated salt.

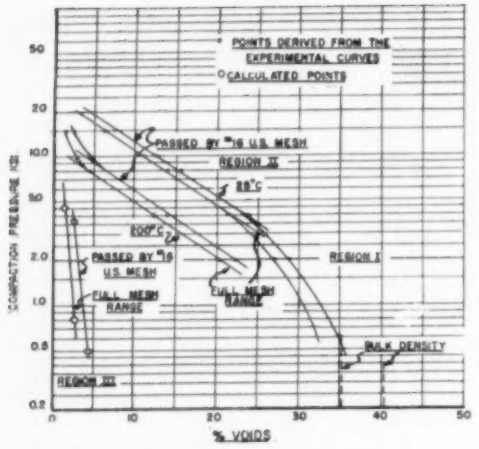

Figure 6. Compaction pressure vs. percent voids for rock salt fines.

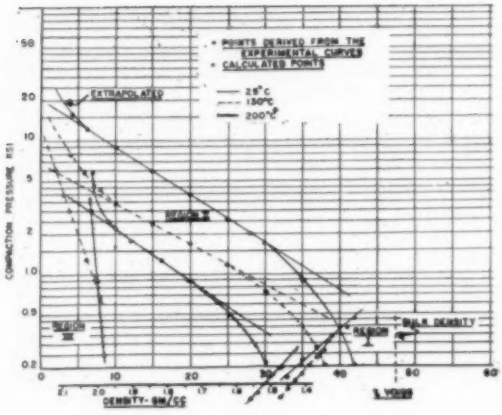

Figure 7. Compaction pressure vs. percent voids for precipitated sodium nitrite.

crushing of granules and more plastic deformation. At zero void content application of additional pressure causes pure deformation (Region IV). Such deformation may be elastic as well as plastic but there is some experimental evidence indicating that elastic deformation is unimportant, at least for the compaction of salt. No significant elastic deformation was observed during the experimental determinations of compaction curves. However, the rate of pressure rise between the rolls of an actual compactor is very much faster than in the closed die used for obtaining compaction data, hence there may be significant elastic deformation in actual operation.

The transition between Region I and II, that is, the point at which the feed becomes cohesive, occurs at the angle of nip according to the postulated mechanism for compaction between rolls. The transition between Region II and III must then occur at some angle at which the void content is on the order of 10% and the transition to Region IV occurs at some lesser angle where the void content becomes zero.

Equations 2 and 3 are based on the assumption of no plastic deformation, hence, these equations must be modified in order to be applicable to void contents less than about 10%. If it is assumed that the function of Region II represents compaction with negligible plastic deformation, then the divergence of the pressure versus void-content curve from the extension of the Region II line represents the effect of plastic deformation. Figure 8 presents a plot of the differences between the extrapolated function of Region II and the actual void content curve against the predicted void content. These differences may be added to the void contents obtained by Equation 2 to yield results corrected for plastic deformation. Figure 9 shows the effect of the plastic deformation correction on the void content versus angle relation.

The correction of Figure 8 may be expressed by the equation:

$$V_i' = m + nV_i$$

Where the function of Region II is given by:

$$P_{II} = Be^{-bV_i}$$

and the function of Region III by:

$$P_{III} = Ce^{-cV_i}$$

The relation between void content

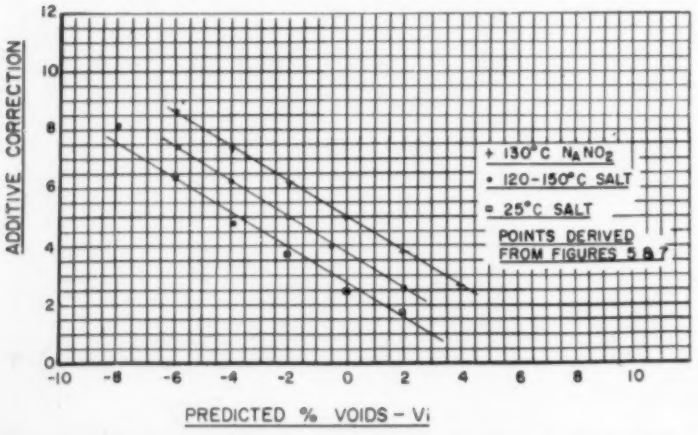

Figure 8. Additive correction to Equation 2 for the effect of plastic deformation.

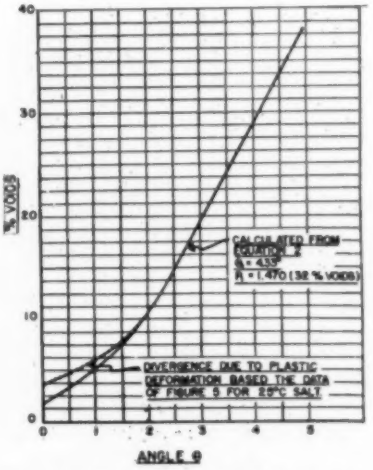

Figure 9. Effect of plastic deformation on percent voids—angle relation.

and angle corrected for plastic deformation is now given by Equation 6, below, where V_i is equal to the first member of Equation 6, this equation holds from the angle of nip down to some angle where the void content becomes zero.

The decrease of void content in Region I, above the angle of nip, is due to reorientation of the granules composing the feed. It is not possible to say how the void content varies with angle in this region, however, the pressure exerted in this section is very small. A reasonable void content gradient may be assumed by extrapolating the gradient obtained below the angle of nip until the void content of the uncompacted material is reached. The error induced in the calculation of the total bearing load by this approximation is negligible.

The expression derived for the angle of nip will be affected by plastic deformation in the same way as Equation 2. The corrected equation appears below as Equation 7, where V_S'' equals the product void content corrected for plastic deformation and V_S is given by the extrapolated function of Region II.

Calculation of forces on rolls

By using the derived equations, the total force developed on the rolls may be calculated.

Typical operating conditions for a compactor operating on fine salt are:

Feed Temperature	25° C
Moisture Content of Feed	0.1-0.2%
Void Content of Product	4.0%
Bearing Load	150-155-kips/bearing
Flake Thickness	0.120 inches

The compaction curve for dry, fine salt at 25° C of Figure 5 is applicable. It is most important that the material for which the compaction curve was obtained be representative of the actual feed stock to the compactor, particularly in regard to granulation.

The angle of nip may be calculated from Equation 7, using the compaction curve, roll diameter, roll gap, and product void content. This is determined to be 4.33° for the example considered.

From Equation 6, the relation between void content and angle is determined. Equation 4 is integrated by plotting $P\cos\theta$ vs. θ where the values of P are determined by combining the void content-angle relation with the experimental compaction pressure-void content relation of Figure 5. Figure 10 illustrates this integration, which yields an answer of 312 kips total bearing load, or 156 kips/bearing. This is extremely close agreement to the measured value of 150-155 kips/bearing.

For operation with a hotter feed (120° C) and the same flake thickness, the angle of nip is calculated to be 3.92° and the bearing load equals 137 kips/bearing, which agrees very well with the measured bearing load of 135-140 kips/bearing.

A second interesting illustration is the operation of a compactor operating on sodium nitrite. Early attempts to operate this machine to produce a thin flake (0.025 in.) resulted in excessive bearing loads.

The void content of product of this thickness is essentially zero. Assuming an angle of nip of 4.33° for fine sodium nitrite at 25°C, the void content-angle relation is determined as before and the integration of Equation 4 performed. This is shown on Figure 11.

The calculated bearing load is 264 kips/bearing while the allowable load is only 150 kips/bearing. Thus, the observed overload is predicted by the theoretical equations.

This problem was eventually eliminated by decreasing the angle of nip by holding a very small head of feed above the nip of the rolls.

Factors influencing compactor design

The factor most difficult to evalu-

$$V_i'' = \frac{\rho_0 - (D_R - D_R\cos\theta_1 + D_S)\rho_1/(D_R - D_R\cos\theta_i + D_S)}{\rho_0} + m + nV_i \qquad (6)$$

$$\cos\theta_1 = 1 + \frac{D_S}{D_R}\left[1 - \frac{1 - (V_S'' - (m + nV_S))}{1 - V_1}\right] \qquad (7)$$

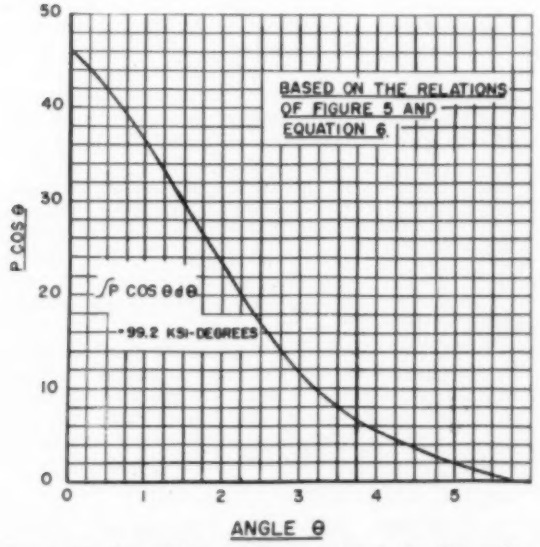

Figure 10. Horizontal pressure vs. angle in the rolls for the compaction of salt at 25°C.

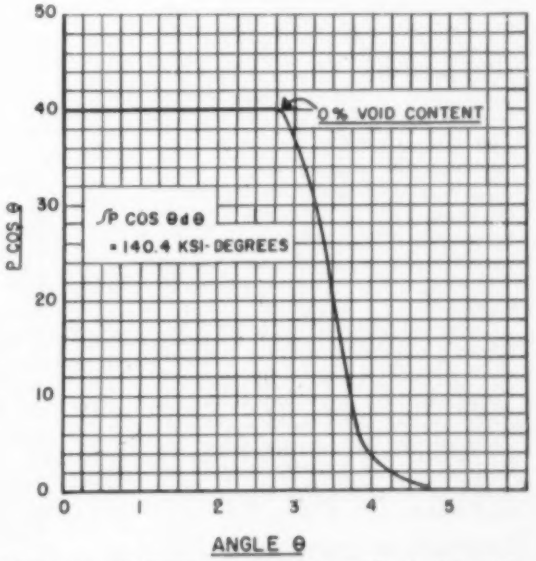

Figure 11. Horizontal pressure vs. angle in the rolls for the compaction of sodium nitrite at 25°C, based on the relations of Figure 7 and Equation 6.

ate in design of a compactor for a given substance is the angle of nip. Its value is determined by the nature of the feed and characteristics of the compactor, and it sets the possible range of product void content and thickness obtainable. The influence of various factors on the angle of nip is summarized below:

1. Frictional drag between the feed and roll faces.

Increased frictional drag increases the angle of nip. Operating experience has confirmed this, as corrosion pitting of the rolls of a compactor tends to decrease the void content of the product.

2. Head of feed above the compactor.

Compactors are normally operated with a full head of feed above the rolls. As mentioned in connection with the compaction of sodium nitrite, the angle of nip may be reduced by feeding the compactor slowly enough to lower the head of feed. On the other hand, experimental work has been done by others in force-feeding the rolls with a vertical screw and thus increasing the angle of nip. This technique would be useful for very free-flowing materials which would otherwise be difficult to compact.

3. Flow properties of feed.

A cohesive feed will exhibit a larger angle of nip than a free-flowing feed. Thus, fine salt exhibits an angle of nip of 4.33° at 25°C and 3.92° at 120°C. The flow properties are visibly better at the higher temperature.

4. Roll speed.

The effect of roll speed has been investigated only slightly. Increasing the speed of an 18 in. diameter machine from 26 to 34 rpm caused approximately a 15% reduction in the original flake thickness of 0.120 in. This was assumed to be due to a reduction in the angle of nip.

It is most desirable to determine the angle of nip by operation of prototype equipment, however, for design purposes the angle of nip may be estimated at 4 to 5° for most granular substances.

In accordance with Equation 7, increasing roll diameter for a constant void content increases the product thickness or, for a constant thickness, decreases the product void content. Thus, in the first example given, increasing the roll diameter from 18 in. to 24 in. should lower the product void content from 4.0% to 2.2%.

Compaction power requirements

The power required to produce compacted product of a given void content may be obtained from the compaction curves. The power requirements are given by:

$$P_W = \frac{0.000073\,R}{\rho_0} \int P d \frac{1}{(1-V_i'')} \quad (8)$$

where the compactor throughput is given by:

$$R = 0.00108 E_S D_S D_R L S \rho_0 (1-V_s'') \quad (9)$$

NOTATION

D_1 = horizontal separation between roll faces at θ_1.

D_R = roll diameter.

D_S = minimum separation between roll faces at $\theta = 0$.

E_S = fraction of a homogeneous sheet obtained from the compactor.

F_H = horizontal force exerted on the bearings of the compactor rolls, kips.

L = length of the active roll face, inches.

P = pressure exerted by the material undergoing compaction on a certain portion of the roll face, kips/sq. in.

P_W = compaction power requirements, hp.

R = compactor throughput, tons/hr.

S = roll speed, rpm.

V_1 = void content of the material between the rolls at the angle of nip.

V_i = void content of the material between the rolls at θ_i.

V_S = void content of the product when there is no plastic deformation during the compaction process.

V_S' = additional void content of the product caused by the effects of plastic deformation.

V_S'' = actual or measured void content of the product.

θ_1 = angle of nip.

θ_i = angle in the compactor rolls as defined by Figure 5.

ρ_1 = bulk density of the material between the rolls at θ_1.

ρ_i = bulk density of the material between the rolls at θ_i.

ρ_S = bulk density of the material between the rolls at $\theta = 0$.

ρ_0 = density of the material between the rolls when the void content equals zero.

The correlation between the predicted power requirements and those observed is quite good and is entirely adequate for design purposes. If very low void contents are encountered during the compaction, the plastic deformation occurring will result in a considerable elevation in the product temperature which may represent a significant portion of the power requirements. For the compaction of salt to a product void content of 4.0% a negligible product temperature rise was observed. For the compaction of sodium nitrite to a product void content of 0% a temperature rise on the order of 150°C was observed, which accounts for the greatest part of the power required. On the basis of simple compaction work, only about 10% of the actual power requirements would be predicted. An additional complication is introduced in the case of sodium nitrite by the presence of a crystal transformation which alters the compaction properties of the material between the rolls.

Conclusions

The design procedure for compactors may be outlined as follows:

1. Determination of the pressure-void content relation for the substance to be compacted at the conditions of granulation, temperature, and moisture content anticipated.
2. Determination of the angle of nip, either by an experimental run on a prototype compactor, Equation 7, or by qualitative comparison with substances of known angle of nip.
3. Selection of product void content and thickness according to the desired properties of the product.
4. Determination of required throughput, including allowance for recycle from granulating and screening equipment.
5. Determination of roll diameter and bearing load from the first three considerations, Equation 6.
6. Determination of power requirements from the first, third, and fourth considerations, Equations 6 and 8.
7. Determinations of compactor roll width and number of machines, as well as roll speed within limits, from the fourth considerations, Equation 9.

ACKNOWLEDGMENT

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An economical char process

.... *how soon?*

The increasing demand for carbon as a reducing agent creates a demand for char, the result of the carbonization of non-coking coals. Char could be used as the carbon source in the processing of taconite, phosphorous, and non-ferrous metals. The creosote-like residue could be used as a wood preservative.

DURING THE FIRST YEARS of this century a multitude of low-temperature carbonization processes were developed for non-coking coals (*1, 2, 4, 5*), some of which never passed the design state. Some were tried out in laboratory or pilot-size units, and some in commercial-size plants. None were unqualified successes. In retrospect, the difficulties seem to have been due to the unavailability of proper materials of construction, difficulty in collecting the volatile portions, and lack of markets for the tars and oils produced. Further, the char had to compete pricewise with coke breeze which, more often than not, was in oversupply. This situation has been altered considerably, in that coke breeze has a ready market. Today we find that coking coal is not as abundant as formerly, and that proper selection of charge stocks can reduce the production of breeze. (The decline in the availability of breeze has led to a stronger demand for anthracite fines, but these are limited by production rates and location.)

Non-coking coals are in great abundance throughout most of the United States, and char, which results from their carbonization, could be readily available. Modern high temperature alloys make it possible to design equipment to carry out the charring operation at an economical cost. Finally, the ever increasing demand for carbon as a reducing agent creates a market which might be filled by char. Examples of where char appears to be an acceptable form of carbon are: taconite roasting, non-ferrous metal smelting, and the production of elemental phosphorus.

If the charring temperature is sufficiently high, and the proper grade of sub-bituminous coal is used, the volatile portion may contain a distillate fraction which would be a suitable wood preservative. The light oil and the tars have a ready market as solvents and coatings, respectively. Thus, it appears that there may be a place in the economy for an efficient char process.

With these economic factors in mind, a group of businessmen from Lewiston, Idaho, founded P.D.P. Processing, Inc. This group erected a small plant at Melstone, Montana, basing their designs, more or less, on the Hobson patent (*3*). This plant never operated successfully. Failure appears to have been due to improper materials of construction and inability to condense the volatile fraction. In 1954 the process was moved to the laboratories of the Engineering Experiment Station at Montana State College. A 3-ton a day pilot plant has permitted development to be carried on there ever since. In 1957 a commercial-scale plant was constructed and operated briefly at Red Lodge, Montana, based on the work done at Montana State College. Char and distillate of the quality noted in this article were produced in the initial operating period of this plant. Subsequently, the plant was operated by the owners in a manner that was detrimental to the retort, and so the plant has now become inactive.

Pilot plant retort

A simplified diagram of the pilot plant at Montana State College is

. . . Non-coking coals are in great abundance throughout most of the U. S., and char, which results from their carbonization, could be readily available.

shown in Figure 1. The retort is made up of four vertical, concentric stainless steel cylinders. An outer shell which houses the retort is made of mild steel and has a diameter of 58 inches. The four inner cylinders, which comprise the heated part of the retort are 12, 20, 24, and 38 in. diam. A loose Zonolite insulation is placed in the annular space between the shell and the outer cylinder. The coal being charged is weighed, carried to the top of the retort in five-gallon buckets and fed into the four hoppers. The coal then flows by gravity through the two-inch annular space between the second and third cylinders. The second cylinder is given a slight vertical movement by a mechanical lift. This helps to prevent bridging between the two cylinders, thus insuring a uniform product because no channels form. The retort stands 11 ft., 4 in. high from the floor. The height of the annular space through which the coal flows is 34 in. Air is prevented from entering this annular space by water seals at both top and bottom.

The charred coal drops from the annular space into a funnel type stainless steel shell at the bottom of the retort, then into an auger box, and is removed by two screw conveyors. The throughput, and thus the volatile-matter content of the char, can be varied greatly, depending upon the speed at which the conveyors are operated. The char then drops into a water-sealed barrel. When the barrel becomes full, it is removed, weighed, and a new one put in its place. The char is allowed to cool and is stored on an open-air concrete deck.

The gases and vapors driven from the coal during the charring operation escape from the coal zone through louvers, fixed into four vertical slots which bridge the outer heat zone. The louvers, Figure 1, are arranged similar to Venetian blinds, except that the louvers are fixed in position. The gases and vapors are pulled through the gas manifold by a blower located in the recovery system. Next, the gases pass through a cyclone which removes any dust that may be entrained in the gas stream. There is a heat jacket around both the manifold and the cyclone to prevent the volatile matter from condensing out.

The dust-free gases are then sent to three condensers operating in series. Water and oils are condensed by a cold water spray at the top of each condenser. The temperature of the last condenser is maintained under 100°F to make certain that most of the condensable matter is removed from the gas stream. A centrifugal pump forces the condensed water and oils from the bottom of the condensers to a decanting drum. The tars are removed from the bottom. Water taken off the top is sent through a heat exchanger, where it is cooled, and forms the cold-water spray for the condensing system. The permanent gases are flared. In a commercial plant these gases would probably be used to heat the furnace.

The charring of the coal is accomplished by hot combustion gases from the furnace. These gases enter the outermost annular space near the bot-

Table 1. Coal and char analyses and yields.

			Coal Analysis					Char Analysis					Yields		
Name	Type	Location	H_2O	Vol.	F.C.	Ash	S	H_2O	Vol.	F.C.	Ash	S	Char %	Oils gal/ton	Gas SCF/T
Brophy Coal Co.	Bit. (w)	Red Lodge, Mont.	11.8	32.2	48.5	7.5		1.1	5.0	83.5	11.5	1.6	53.5	25.0	6450
Mont. Coal & Iron	" (w)	"	6.0	38.3	48.7	7.0			4.0	84.0	12.0	1.1	53.4	20.4	6500
Janskovich Coal Co.	"	"	8.1	33.1	43.6	15.2			4.6	71.4	24.0	3.2	51.6	9.4	
Burns Coal Co.	"	"	6.0	38.0	42.0	14.0			4.0	70.0	26.0		53.8	12.8	
E. Belt Coal Co.	"	Belt, Mont.							4.0	81.3	14.7	2.6	74.7	5.8	3840
Ind. Coal & Coke	"	Spring Canyon, Utah	3.7	42.4	49.8	4.1			5.4	87.4	7.2		65.6	35.0	8000
Mtn. St. Mining Co.	Sub-bit.	Roundup, Mont.	12.7	30.5	47.3	9.5			4.0	82.0	14.0	0.3	48.0	8.5	
Roundup Mining Co.	"	"	10.1	31.0	52.8	6.1			4.0	85.6	10.4	0.2	61.5	8.9	5850
Square Deal Mining	"	"	11.2	31.4	50.7	6.7			1.9	86.5	11.6	0.1	58.6	10.7	
Johnny's Coal Co.	"	"	13.6	35.4	46.2	4.8			2.9	88.1	9.0	0.3	52.4	12.0	
Divide Coal Co.	"	"							3.8	88.8	7.4	0.4	48.1	10.3	
Gildroy Coal Co.	"	"							4.1	86.0	9.9	0.4	52.2	14.0	
P. M. Coal Co.	"	"	4.7	34.8	54.6	7.0			4.0	84.2	11.8		59.2	11.7	
N. W. Improv. Co.	"	Colstrip, Mont.	14.2	36.1	40.5	9.2			6.2	76.4	17.4		50.2	14.0	7900
Big Horn Coal Co.	"	Sheridan, Wyo.	22.3	33.8	39.4	4.1			4.6	88.0	7.4		50.2	19.0	8000
D. O. Clark Mine	"	Superior, Wyo.	13.9	33.8	48.4	3.9	1.1		3.2	91.2	5.5	0.7	54.2	27.1	6040
Monolith P. Midw.	"	Hanna, Wyo.	9.5	40.0	44.8	5.7	0.2		3.0	86.0	11.0	0.1	54.3	26.0	7500
Kemmerer Coal Co.	"	Rock Springs, Wyo.	3.3	40.7	52.8	3.2			3.0	92.7	4.3	0.7	52.0	20.1	6000
Kemmerer Coal Co.	"	Frontier, Wyo. (Elkol)	20.2	35.6	42.6	1.9			2.8	94.6	2.6		49.8	15.0	7500
Best Coal Co.	"	Bill, Wyo.	24.7	32.6	38.6	4.2			4.2	88.5	7.3		55.0	12.6	6540
Wyodak Coal Co.	"	Gillette, Wyo.	27.5	33.1	32.8	6.6			3.0	82.0	15.0		45.6	20.0	6400
Nugget Coal Co.	"	Hanna, Wyo.	12.0	40.9	42.3	4.8			5.0	88.8	6.2		54.0	24.0	7500
North Star Coal Co.	Lignite	Coalwood, Mont.	47.2		45.1	7.5		5.0	4.0	76.8	14.2	0.05	49.3	4.2	
Thiel Bros.	"	Sidney, Mont.	44.3		47.5	8.2		5.0	4.0	73.0	18.0		45.7	5.7	
J. Albrecht	"	Bloomfield, Mont.	51.6		45.0	4.4		5.0	4.0	76.2	14.8	0.2	51.2	4.8	
Peuse Bros.	"	Glendive, Mont.	47.4		48.2	4.4		5.0	4.0	83.4	7.6	0.1	40.6	3.1	3060
C. Sorenson	"	Savage, Mont.	48.3		44.4	7.3		5.0	4.0	76.5	14.5		50.2	4.8	
Truax-Traer Coal	"	Truax, N. D.	31.5	29.6	32.1	6.8			7.4	78.6	14.0		50.0	7.9	
New Engl. Coal	"	New England, N. D.	35.0	27.6	27.2	10.2			5.5	69.0	25.5		48.6	7.2	
Knife River Coal	"	Beulah, N. D.	11.6	31.5	45.2	11.5			9.7	72.4	17.9		50.2	8.0	5800

tom of the retort and travel upward and then downward through the innermost annular space. Thus, the coal is heated on both sides as it is retorted. The gases are pulled by a blower up through the inner tube and are recycled to the furnace.

The outside dimensions of the furnace are: 11 ft., 4 in. long; 5 ft., 4 in. wide; 7 ft., 8 in. high. The walls are constructed of two rows of firebrick covered on the outside with a course of insulation brick. A mild-steel shell encases all four sides of the furnace. The roof, unattached to the walls of the furnace, is hung in place from three I-beam stands, shaped like inverted U's. The roof is made of plastic firebrick, which may be molded into shape before hardening. The floor of the furnace is made of one course of firebrick and one course of insulating brick on top of ventilation tile. Air is blown through slots in the ventilation tile and water pipes are placed between each row. In this way the furnace floor can be kept relatively cool so that the heat from the furnace will not crack the concrete floor of the laboratory.

There is an 18-in. firebrick baffle two-thirds of the way back in the furnace. The hot gases pass over the baffle and mix with the recycled gases from the retort insuring better combustion and a more uniform heat flow. The amount of natural gas fed as fuel to the furnace is regulated by an automatic controller which keeps the output temperature constant, usually at 1700°F.

Temperature readings are taken every half hour throughout a run by means of thermocouples. The two most important temperatures are at the outlet of the last condenser, and the char-discharge temperature. The latter is kept in the range 1300-1500°F. This has been found to be sufficient to drive off the required amount of volatile matter. The char-discharge temperature is best regulated by varying the speed of the discharge augers. A faster throughput will lower this temperature.

Results

A number of different western coals have been tested in the pilot plant. The principal ones are listed in Table 1. A wide variation in composition will be noted. The charring operation removes all of the moisture and most of the volatile matter but has little or no effect on the fixed carbon and ash. Thus, to make a low-ash char, a low-ash coal must be charged. Whether or not the process is self-sufficient with respect to heat depends upon the amount of non-condensable gas produced and the moisture content of a given coal. Of the coals listed in Table 1, the lignites produce insufficient gas and contain too much moisture to be heat self-sufficient. To operate with one of the lignites on a commercial basis, one must be prepared to use a supplemental source of heat, or a coal drier, first. The coal from the

Table 2. Comparison of creosote from Red Lodge, Montana, coal with American Wood Preservers' specifications.

A.W.P.A. Specification P1-54	Creosote from Red Lodge Coal
1. It shall contain not more than 3% water	1. No water.
2. It shall contain not more than 0.5% of material insoluble in benzol.	2. 0.85%
3. The specific gravity of the creosote at 38°C compared with water at 15.5°C shall be not less than 1.03.	3. Specific gravity is 1.032.
4. The distillate on a water-free basis shall be within the following limits:	4.
Up to 210°C 5%	5.0%
Up to 235°C 5-25%	22.2%
Up to 315°C 20%	71.4%
Up to 355°C 60-85%	82.6%
5. The specific gravity of the fraction between 235-315°C shall be not less than 1.025 315-355°C shall be not less than 1.085 at 38°C compared with water at 15.5°C.	5.
6. The tar shall yield not more than 2% of coke residue.	6. 4.23%

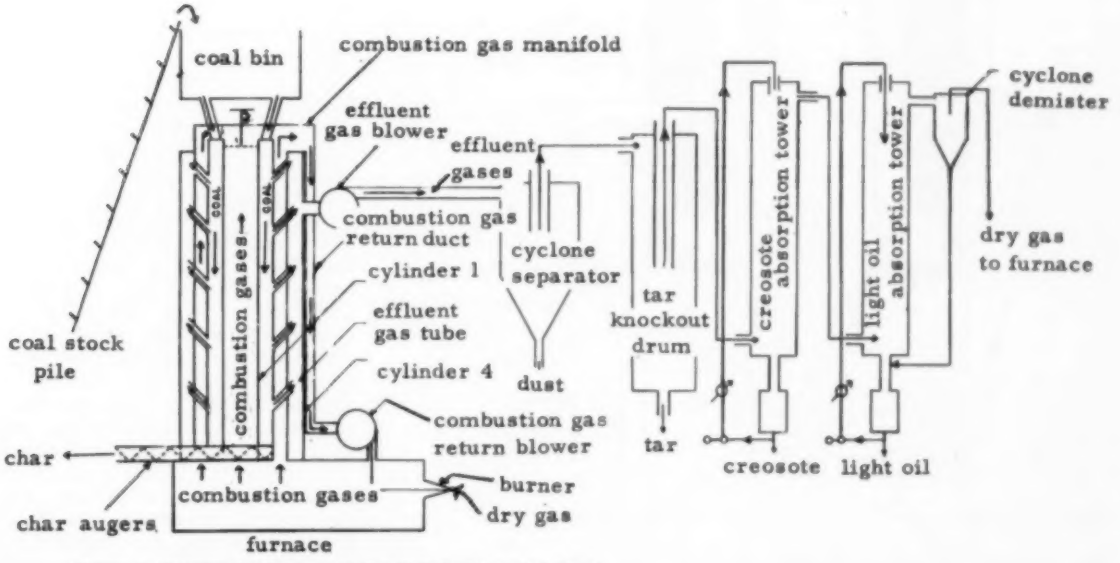

Figure 1. Schematic diagram of the M.S.C. Char pilot plant.

Sheridan, Wyoming, deposit contains so much moisture, that the heat balance is close. The others produce an excess of gas above that required for retorting.

The char data in Table 1 are experimental. No significance should be attached to the variation in volatile-matter content of the char. The amount of residual volatile matter is a function of the time-temperature history of the char and can be varied over a wide range. In fact, with a very high rate of throughput, the retort approaches a coal drier in operation; it removes most of the moisture, but very little of the volatile matter. In this case, however, it is far from heat self-sufficient. Minimum volatile-matter content attainable in the char is in the range of 1-2%. As mentioned above, fixed carbon-to-ash ratio cannot be altered and a high-ash coal yields a high-ash char.

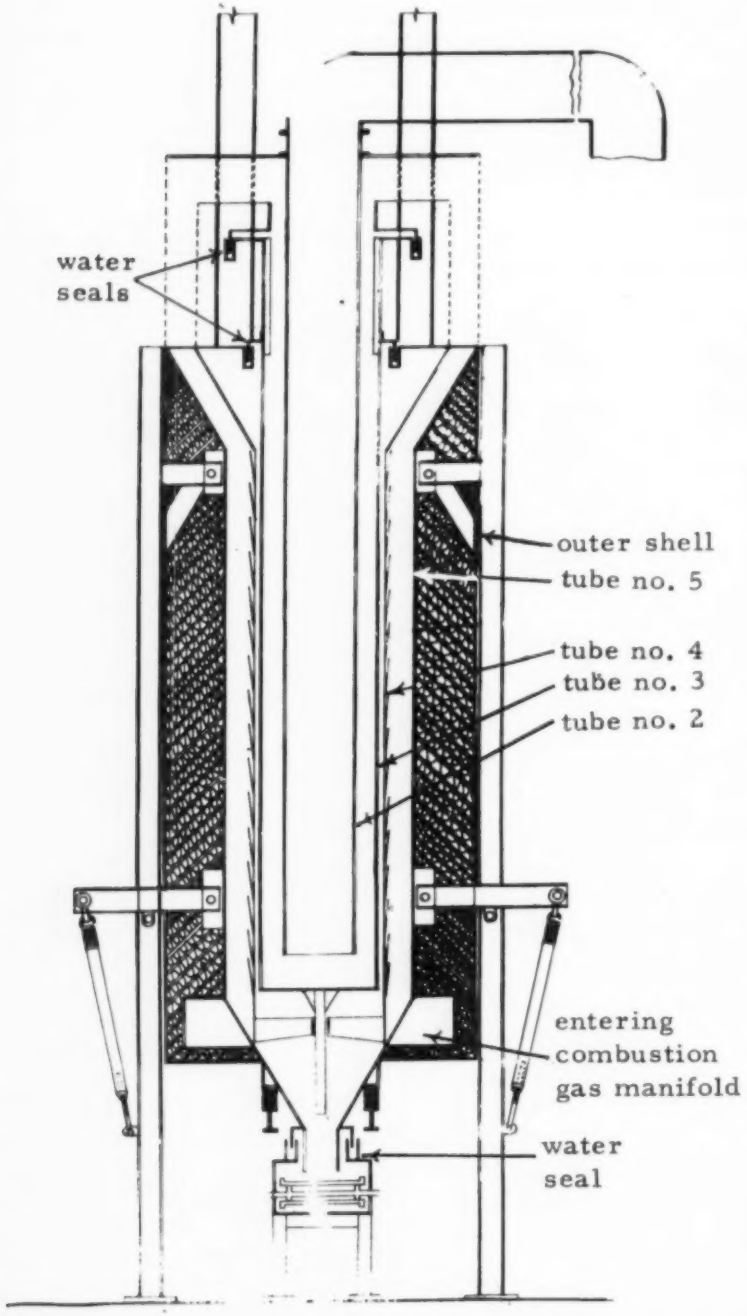

Figure 2. Detail of the commercial size retort used at Red Lodge.

The yields of char, oils, and gas vary considerably with the different coals. The extent of the difference can be seen in Table 1. Highest char yields were obtained from Belt, Montana, and Spring Canyon, Utah, coals, 1490 and 1310 lb./ton, respectively. The high ash and sulfur content, and the low yield of oils make the Belt coal economically unattractive. The lowest yields of char result from the lignites. For example, Glendive, Montana, lignite gives only 812 lb./ton. The yield of oils varied from a high of 35 gal./ton from Spring Canyon, Utah coal to 3.1 gal./ton from Glendive, Montana, lignite. About the only valid generalization that can be made from the data in Table 1 is that lignite gives a poor oil yield. The yield of gas is given as std. cu. ft. of dry gas/ton of coal. The gas has a composition typical of coal gas, principally methane and hydrogen, and a heating value of approximately 550 Btu./cu. ft. Analyses were not made of each coal gas.

The yields in Table 1 do not add up to 100%. The two principal sources of loss are (1) dust, which was separated in the cyclone separator and discarded, and (2) inability of the condensers to remove all of the lighter portion of the oils as liquid. The dust was not considered as part of the char yield and the escaping light oil was not added to the dry gas volume.

The yield of oils is even harder to predict from the coal analysis. Since this investigation has been confined, so far, to western coals and to an area where the market demand for creosote is good, little consideration has been given to making liquid products other than creosote-type materials. Experiments to date indicate that creosote meeting the specifications of the American Wood Preservers' Association has not been made through the operation described above. There is no doubt, however, but that a salable wood preservative material can be produced. The char analyses and yields obtained in these coal studies are presented in Table 1. Table 2 shows a comparison of creosote from Red Lodge coal with American Wood Preservers' Association Specification P1-54. Specification grade is worth

about 22¢/gal. Non-specification grade wood preservative is currently being sold for about 14¢/gal.

It is obvious that the economic attractiveness of a distillate fraction of the process would vary greatly with the coal charged. The char must be of a quality that is attractive for the particular user. For example, the nonferrous smelters want char containing less than 5% volatile matter, sized to 3/16 in. minus, and containing at least 75% fixed carbon. The elemental phosphorus manufacturers want char containing less than 1% sulfur, less than 2% volatile matter and at least 85% fixed carbon, sized in the range ¾ in. by 3/16 in. For the zinc fume smelting operation, the char should contain 10-15% volatile matter and be sized to −200 mesh.

Of the several coals listed in Table 1, only those five were selected for economic comparison which have evoked the greatest interest at the present time. The authors do not wish to preclude the others from consideration, however. The chars from Red Lodge, Montana, Spring Canyon, Utah, and Superior, Wyoming, coals seem to come closest to meeting phosphorus manufacturers' specifications. The char from Roundup Mining Company coal possessed very low sulfur, and its other properties were such that it was deemed satisfactory for use in ferrochrome manufacture. Since there appears to be a ferrochrome industry beginning reasonably close to Roundup, Montana, it was included for consideration.

Considerable interest has been shown in attempting to use lignite char in the reduction of taconite. Of the lignites tested, that from Beulah, North Dakota, is typical and of possible interest.

Commercial Plant

A commercial plant was constructed at Red Lodge, Montana, comprising one retort with condensing and absorbing equipment of a capacity sufficient to handle two additional retorts. Figure 2 is a diagram of the Red Lodge retort. It is 24-ft. high × 9-ft. O.D. Tubes No. 1 and 4 are of Type 309 stainless steel; the remainder of the retort is constructed of Type 304 stainless steel. The outer shell, supports, ducts, and pipes are mild steel. The tube on the inside of the coal is moved up and down a distance of about 1½ in. by a hydraulic cylinder and pump attached to the yoke. This facilitates free flow of coal through the annulus without imposing the strain on the retort of a rotary motion.

The furnace is 14 ft. long, 8 ft. wide and 9-ft. high, made of firebrick with clip-on type brick on steel I-beams, and plastic fire clay for the roof. The three absorbers arranged in series are cylinders 14-ft. high × 4-ft. diam. with sprays at the top. They dip into receiving tanks having a diam. 4 in. greater than the absorbers. Creosote and water condensed in the absorbers overflow to creosote storage, from whence they are periodically pumped out and run through a centrifugal oil purifier to remove the water.

The char is withdrawn from the bottom of the retort by means of a stainless steel auger driven by a variable-speed drive. The char drops into a char conveyor, which is an auger, and then to a bucket elevator. From this the hot char is dropped into a trommel-type cooler which consists of a slightly tilted rotating cylinder 20 ft. long × 4-ft. diam., equipped with six water sprays on the outside. Near the lower end is placed a ¾-in. screen in the cylindrical surface of the cooler through which the fines drop. The coarse char falls out of the end of the cooler.

Thermocouples are placed at several points, and during operation, the temperatures are as follows: heat inlet duct, 1800°F; heat return duct, 1200°F; char leaving the retort, 1100-1200°F; entrance to first absorber, 500°F; entrance to second absorber, 180°F; discharge from third absorber, and entrance to flare, 80-90°F. The furnace was last operated with natural gas. Coal gas, then being flared, would be burned in the furnace if additional retorts were installed.

Washed Red Lodge slack coal was charged at the rate of 40 tons/24-hr. day and about 20 tons of char and 18-20 gal. of crude tar per ton of coal were produced per day. Table 3 presents the analytical data on the coal charged and the char produced. The analysis of the crude tar is presented in Table 4.

Table 3. Analyses of Red Lodge coal and char.

	Coal	Coal	Char	Char
Size, in.	1¼x¾	¾x0	1¼x¾	¾x0
Moisture, %	13.3	12.6	1.08	0.9
Volatile Matter, %	36.2	34.2	3.76	3.3
Fixed Carbon, %	43.2	39.2	82.5	85.5
Ash, %	7.3	13.9	13.7	10.3
Heating value—Btu./lb.	10,720	9780	12,380	12,380
Sulfur, %	1.7	1.8	1.62	1.62
Phosphorus, %	N.D.	N.D.	0.019	0.019
Ultimate analysis of ash				
Silica (SiO_2), %		38.40		
Alumina (Al_2O_3), %		12.03		
Iron oxide (Fe_2O_3), %		23.76		
Calcium oxide (CaO), %		8.08		
Magnesia (MgO), %		4.20		
Potassium oxide (K_2O), %		1.55		
Sodium oxide (Na_2O), %		2.85		
Sulfur trioxide (SO_3), %		8.80		
Phosphorus pentoxide (P_2O_5), %		0.33		

Table 4. Analysis of creosote-coal tar solution from Red Lodge coal.

Water, vol.-%	2.055
Coke Residue, wt.-%	15.2
Specific Gravity at 38°C compared with H_2O at 15.5°C	1.10
Distillation	
up to 210°C	6.84
up to 235°C	17.36
up to 315°C	45.86
up to 355°C	60.61
Distillation Residue Analysis	
Volatile Matter, wt.-%	60.6
Fixed Carbon, wt.-%	39.4
Ash, wt.-%	0.0

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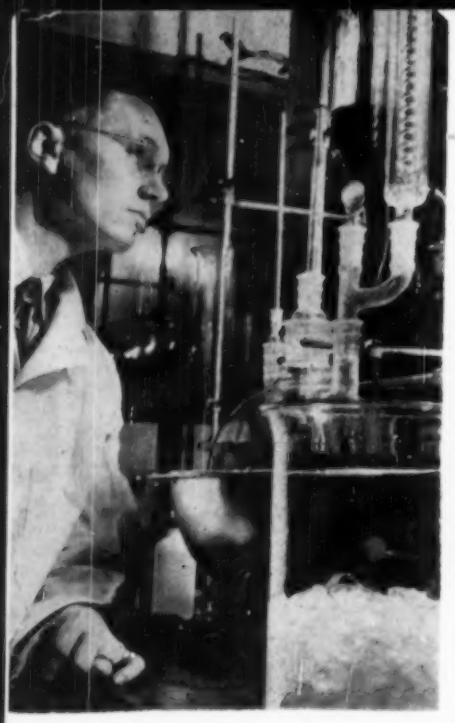

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continued

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G. K. Kullberg* and H. B. Kendall
Case Institute of Technology,
Cleveland, Ohio

Improve heat transfer coefficients

...with silicone resin coatings

Studies conducted in a small condenser have shown that the overall heat transfer coefficients obtained during the condensation of steam on the exterior surface of a silicone resin-coated copper tube are larger than those obtained during condensation on an uncoated tube. The higher coefficients are attributed to the fact that dropwise condensation occurs on the resin coated tube, while condensation is filmwise or "mixed" on the untreated surface.

* Present Address: *Dow Corning Corp., Midland, Mich.*

Heat Transfer Studies

A drawing of the apparatus is shown in Figure 1. The heat transfer tubes used in the condensation studies were ¾" diam. (actual: 0.495" O.D., 0.438" I.D.) and 27" long, cut from soft-annealed copper water tubing. Water lines and fittings were of ½" A.S.A. steel pipe. Steam lines and fittings were of ¾" steel pipe except for the rubber hose which was ½" I.D. with ¼" thick walls. The shell and oxygen absorber were of 51 mm Pyrex glass, the shell 25" in length and the absorber, 7". The actual exposed length of condenser tube was 23". Centigrade thermometers (−10 to 150°) were used for temperature measurement, and steel wool cleaned in benzene was used in the oxygen absorber.

The operation of the exchanger began with a purging of the piping with steam and a period of warm-up during which time cooling water was not flowing. This allowed the steam lines and the glass shell to come to steam temperature. In all runs, the excess steam was vented at the top-center of

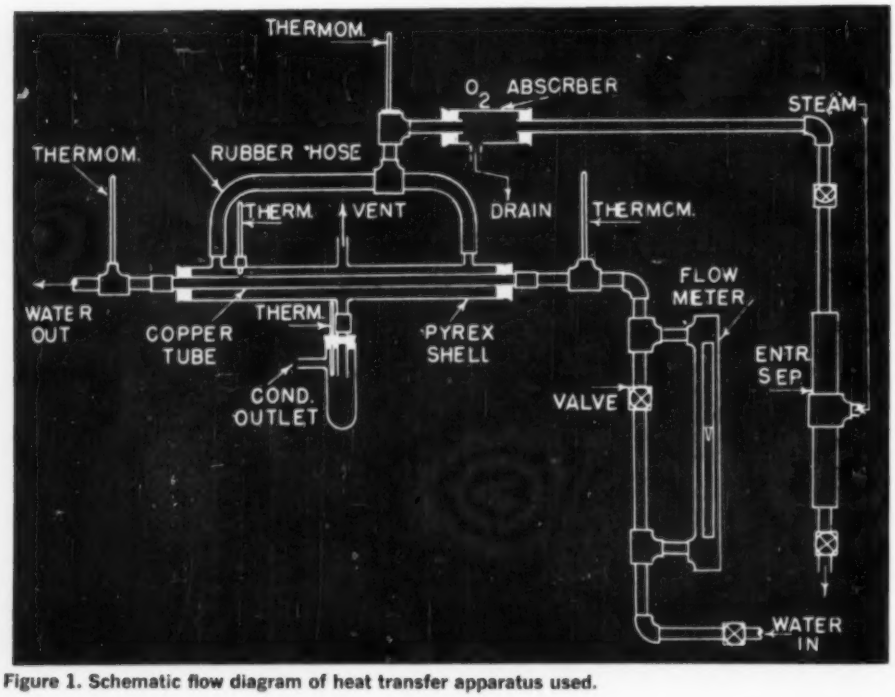

Figure 1. Schematic flow diagram of heat transfer apparatus used.

the shell, therefore all runs were carried out with the steam at atmospheric pressure. The water flow rate was measured with a rotameter.

In taking data, the water rate was adjusted to some value, following which the steam flow was adjusted so that no uncondensed steam passed into the condensate container. When a stability of readings indicated that steady state conditions had been attained, temperatures and flow rates were observed and recorded. The steam rate was obtained by weighing the quantity of steam condensed during a timed portion of the run.

The apparatus was first run using a clean copper tube in order to produce filmwise condensation of the steam on the surface. From the data obtained, overall heat transfer coefficients were calculated, and are plotted in Figure 2 vs. the Reynolds number of the water flowing through the tube. This was done for comparison with the silicone coated tube and to ensure reliable operation of the equipment. The heat transfer characteristics of the silicone coated tube were then examined in the exchanger. Results for this series of runs are also plotted in Figure 2. As the exchanger was operated, the silicone coated tube became brown in color, but this had no noticeable effect on the data nor upon the operation of the equipment.

With the silicone coated tube in operation, dropwise condensation was observed at all times. The drops ran off the tube very rapidly before building up appreciably in size. At the same time, the increase in temperature of the water flowing through the tube was observed to be much greater at a given flow rate than when the steam was condensing as a film on the surface of the bare tube.

Figure 2 shows the increased values of the overall coefficient of heat transfer for the silicone coated tube as compared with the values obtained using the clean tube. One set of data was taken when the clean tube was becoming oxidized. The oxidized surface of the tube appeared to cause a mixed type of condensation—partially in drops, and partially as a film—the degree of each evidently related to the extent of the oxidation. The middle curve in Figure 2 shows the overall coefficients calculated from these data.

In order to obtain estimations of the values for the coefficients of the steam condensing on the tubes, the graphical method suggested by Wilson was used (*11*). The estimates of the steam-side coefficients obtained by this method were:

1700 Btu/ft^2 × hr × °F for filmwise condensation on the uncoated tube,

5500 Btu/ft^2 × hr × °F for dropwise condensation on the coated tube.

Exposure Studies

In attempting to determine the feasibility of using silicone resins for the promotion of dropwise steam condensation, two questions arose. The first of these had to do with whether or not the increased heat transfer brought about by the dropwise condensation on the silicone film would more than offset the deleterious effect of adding another resistance to heat flow. The second question had to do with the endurance properties of the resin film; that is, the stability of the film in the presence of condensing steam. The answer to this second question was actually sought first in the experimental work. The encouragement received from the endurance studies led to the heat transfer investigations described in the preceding section.

The resin used in this study was a silicone resin designated as "R-671" by the manufacturer, the Dow-Corning Corporation, Midland, Michigan. The properties of this resin, as given by the manufacturer are as follows:

(a) **General description:** Dow Corning R-671 Resin is a heat-stable, semipermanent silicone release agent for patterns, molds, and other metal surfaces. The resin withstands temperatures up to 500°F and is highly resistant to chemical attack.

(b) **Typical Properties:**

1. Solids content, after 3 hr. at 275°F 20%
2. Solvent .....aromatic hydrocarbons
3. Viscosity at 77°F (centipoises) 3-8

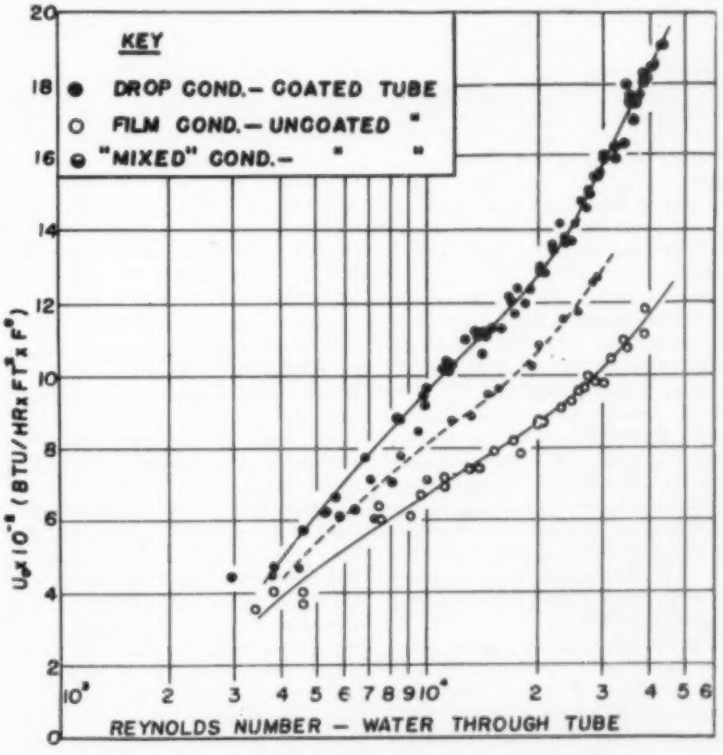

Figure 2. Overall heat transfer coefficients during condensation.

4. Specific gravity at 77°F 0.88

(c) **Application:** The resin can be applied by brushing, spraying, or dipping, and cures to a hard glossy film.

(d) **Curing:** The resin should be cured according to one of the following schedules: 16 hr. at 300°F; 8 hr. at 350°F; 4 hr. at 400°F; 2 hr. at 425°F; 1 hr. at 450°F; or ½ hr. at 475°F.

The steam exposure studies were made using 2″ × 3½″ panels cut from 0.022″ thick copper sheeting and coated with the silicone resin. The panels were cleaned by rubbing with steel wool, washing with boiling detergent water, and rinsing well with water. Panels were dried at 225°F before being coated. The copper tubing used in the heat transfer studies was cleaned in a similar fashion, but fine grade emery cloth was used in place of the steel wool.

The apparatus used to coat the panels and tubes consisted of a four-step pulley arrangement connected to a small synchronous motor. The tangential velocities of the pulleys ranged from 3 inches/min. to 10 inches/min. The slowest speed, 3 inches/min., was the most satisfactory for placing a uniform coat of resin on the objects to be coated.

The coating operation consisted of quickly lowering a panel (or tube) into the resin solution and slowly raising it by means of the synchronous motor and pulley. The coated object was next air dried for 5 to 10 minutes, and the resin was then baked on the metal surface at 425°F for about 2 hours.

The exposure of the panels to steam was accomplished in two steam sterilizers, with one group of panels exposed to saturated steam at 235°F, the other group at 255°F.

First tested were panels coated from a 20% resin solution at various coating speeds. Little variation was noted in the effect of steam on the coatings, but the appearance of the coatings after exposure was best for those coated at the slowest speed (3 in./min.). These panels still caused dropwise condensation after exposure to steam for 1500 hr.

The second group of panels tested were coated with resin at 3 in./min. using solutions of various resin concentrations. A reduction in the resin concentration of the coating solution results in a reduction in the endurance period. The 20% solution is the standard R-671 resin solution, and this was the most satisfactory solution tested.

In order to obtain an indication of the approximate thickness of the resin film on the panels and tubes, a magnetic film gauge was employed. Steel panels were coated at the four pulley speeds and the resin was cured. It was assumed that the resin wet the steel the same as the copper. Film thickness measurements were then made with the gauge and compared with the standards supplied with the instrument. Although all measurements were not reproducible, indications were that the film thickness on all test panels was near 0.0004 inches.

Previous Work

This work was motivated by the well-documented knowledge of many years duration that vapors condensing in a dropwise fashion produce heat transfer coefficients much larger than those condensing in films (*8, 12, 13*). Further, steam is apparently the only pure vapor which definitely condenses in drops, and certain special conditions are necessary before this will occur (*6, 10, 11*). Also, it has been observed (*10*) that dropwise condensation will occur when several materials condense as a mixture, and this latter observation has led to investigations of the use of "promoters" to encourage dropwise steam condensation (*2, 6, 7, 8*). In general, substances that coat the condensing surface and are not themselves wetted by the condensate have proven useful as dropwise condensation promoters. Emmons (*7*), using the techniques described by Blodgett (*3*), found that "one and only one complete layer of promoter molecules on a condenser surface is responsible for drop condensation."

Many materials have been used to promote dropwise steam condensation, for example: petroleum oils and greases, fats, waxes, soaps, mercaptans, and a silicone oil (*2, 6, 8, 9*). These were applied by wiping the condensing surface with a cloth soaked in the promoter or by injecting the material directly into the steam line. Until recently, lack of endurance has been a drawback of these materials. In a very recent paper, Blackman (*1*) has reviewed the use of dropwise condensation promoters and has described newly synthesized organic substances which, when coated on copper tubes, promote dropwise steam condensation for periods of from 500 to 3500 hours. In the same article, the author refers to work by Bobco and Gosman (*4*), where silicone resins were used to promote the dropwise condensation of some organic vapors. Lack of endurance of the resin in the presence of the condensing vapors was again a drawback.

Discussion

This study shows quite clearly that a silicone resin baked on a heat transfer surface has the ability to promote dropwise steam condensation. This results in overall heat transfer coefficients that are appreciably larger than those obtained when steam condenses in a film on an uncoated surface. Thus it can be concluded that the desirable effects of the dropwise condensation are greater than the undesirable effects produced by the introduction of another resistance to heat flow in the form of the silicone coating. Further, unlike many other promoters, the silicone resin coating tends to remain on the surface of the tube for relatively long periods of time, at least in the presence of rather low pressure steam.

The endurance studies are by no means complete. Further work along this line should include exposure of the resin to steam at higher pressures, perhaps on water cooled tubes in order to more nearly approximate exchanger operation. Also, in order to obtain accurate values for the individual coefficients, runs should be made while accurately measuring or estimating tube-wall temperatures.

The value of this work to the designer will not be known until other tests can be made on more nearly commercial equipment under conditions approximating those encountered in actual service. At that time the economics involved in the coating of tube bundles or other heat transfer surfaces might also be ascertained.

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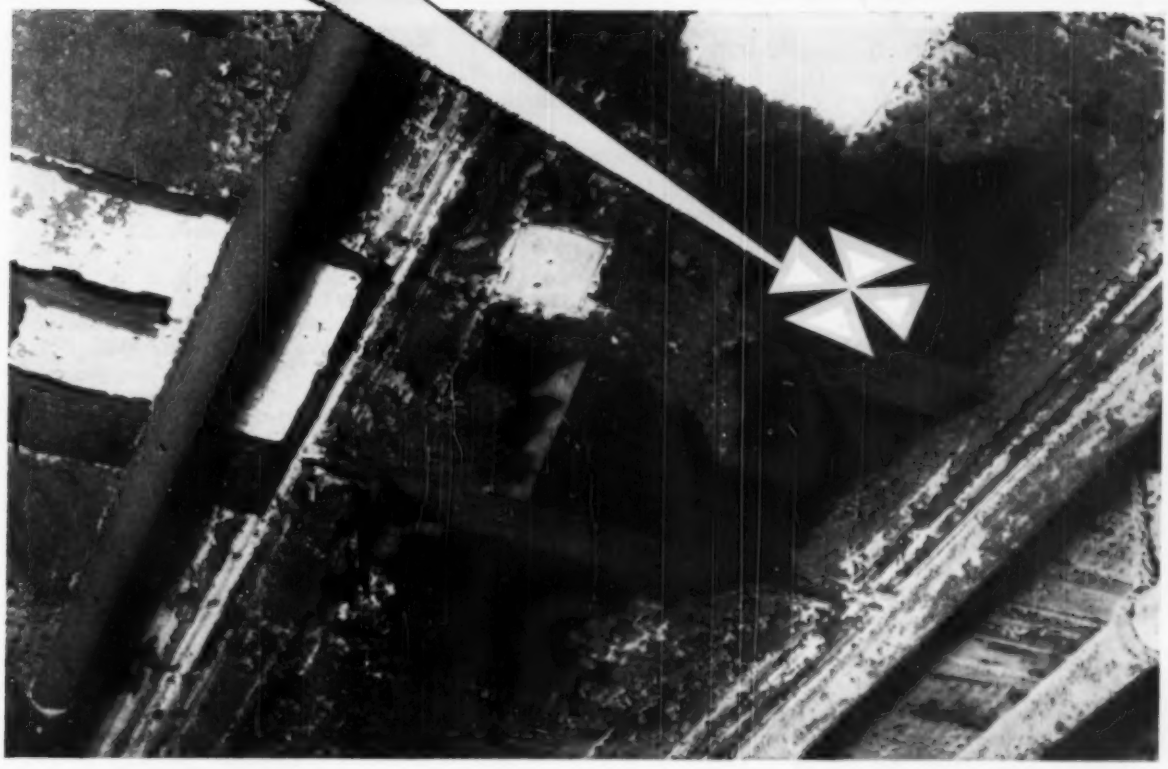
where a $1.05 saving went through the roof!



On a 250 gallon paint order, the Plant Maintenance Department figured to save $1.05 per gallon by using a paint that was cheaper, and "just as good" as Tygon. The cheaper paint *appeared* to be doing a good job — then the roof fell in!

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CEP

COMPUTER PROGRAM abstracts

The Machine Computation Committee of the A.I.Ch.E. is interested in receiving program abstracts. Once again the Committee wishes to emphasize the three rules for participation in the interchange program:

1) Abstracts submitted for publication must follow the form published in *CEP* (January, 1959) and in the *Guide*.

2) Abstracts must be sent to the Machine Computation Committee c/o A.I.Ch.E.

3) All questions relating to published abstracts must be sent to the Committee c/o A.I.Ch.E. in New York.

Equilibrium flash vaporization (012)

Arthur G. McKee & Co.
Oil Process Department
Cleveland 1, Ohio

Description: This program is designed to calculate an equilibrium flash vaporization for a system of hydrocarbons with or without inerts and/or water from the molar composition of the system and any two of the following:

1. Temperature
2. Pressure, and
3. Percent Vapor

The program will utilize K values calculated from surface fits for 29 components. Components not listed may be specified with their K values that have been obtained from nomographs or other available sources.

The method of convergence varies with the particular unknown sought. If temperature or pressure is the unknown factor the basis for a solution will be to compare the assumed temperature or pressure with a value calculated as the next approximate temperature or pressure. The assumed temperature or pressure must agree with the value calculated as the next approximate temperature or pressure within the limits established. When percent vapor is the unknown quantity, that is the L/V ratio, the method used to calculate the split and the basis for the solution depend on the type system being considered. If the system contains inerts or water that is above its dew point, the criteria used for a solution is the partial pressure of the hydrocarbon. If the system contains no water or inerts, or if the water is below its dew point, then the criteria used for a solution is the L/V ratio.

The method used to converge on a solution when the liquid to vapor ratio is the criteria was suggested by Lockhart and McHenry in *Petroleum Refiner*, March 1958. The method reduces a multicomponent mixture into a hypothetical binary mixture and calculates a hypothetical quantity of vapor from the equation:

$$V^\circ = (Fl/l - K^\circ h) - (Fh/K^\circ l - 1),$$

where

$$K^\circ l = (L/V) / (Fl/Vl) - 1, \text{ and}$$

$$K^\circ h = (L/V) / (Fh/Vh) - 1$$

For a binary mixture of l, (the more volatile) and h, (the less volatile) the conventional flash equations readily simplify into the above equations which may be solved directly for V. When the temperature and pressure are given, the program will determine whether a two phase system exists. If a two phase system does not exist, the program will punch a note to that effect.

Computer: IBM 650 with alphabetic attachments.

Program language: Bell L_2

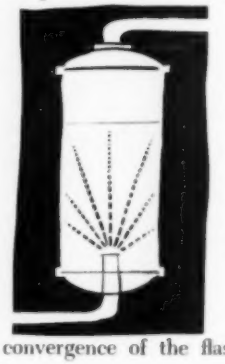
Running time: The approximate machine running time is 18 to 24 seconds per component.

Availability: A program manual has been written and can be made available for publication should sufficient interest develop.

Equilibrium flash distillation (035)

G. G. Bejarano
Mathematical Services Group
California Research Corp.
Richmond, California

Description: This program carries out an equilibrium flash distillation calculation for a specified feed composition, temperature, and pressure. The feed may contain as many as twenty components. The vapor-liquid equilibrium constants (K-values) must be supplied. Feed composition may be specified in terms of barrels, pounds, and/or pound-moles. Both the quantities and compositions of the equilibrium liquid and vapor are determined in all of the above units. In addition, the enthalpies of the equilibrium vapor and liquid streams may be calculated if component vapor and liquid enthalpies are specified. A Newton-Raphson method is used to



obtain convergence of the flash calculation.

Computer:
1. Datatron 205, 4000 words storage, card input and output, and floating point unit.
2. IBM 704, 4096 words storage.

Program language:
1. Datatron 205 Machine Code
2. Fortran

Running time:
1. Four or five minutes depending upon the number of components in the feed.
2. Less than one minute.

Comments: The program has found wide application in process design calculations. It has been used successfully more than one thousand times.

Availability: A manual will be prepared if sufficient interest develops.

continued on page 88

ECO ENGINEERING NEWS

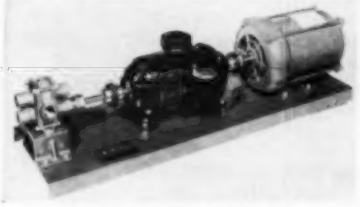
the big name in small pumps for the process industries

Pumping Notes

GEARCHEM Pumps Solve Catalyst Metering Problem

Hanford Nuclear Operations, Richland, Washington, had a real problem in metering, at variable flow rates, a viscous catalyst used to cure silicone rubbers. Impulse diaphragm pumps, as normally used to move this hesitant mass, gave undesirable slug type delivery with unavoidable irregular volumetric yields.

The problem was solved with Eco GEARCHEM pumps in Hastelloy* construction and with Hastelloy gears, driven by Vickers variable speed transmission. These pumps, supplying linear, low capacity flows, provided the essential, dependable metering of the catalyst for uniform end product.



From Viscous Catalysts To Thinner-Than-Water Solvents

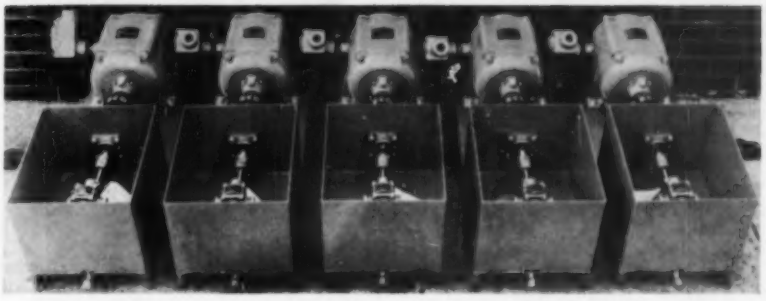
Thus, the GEARCHEM Pump proves its great versatility. The requirements of U.B.S. Chemical Company, Cambridge, Mass., were the exact reverse of Hanford Nuclear Operations outlined above.

Here the problem was the exact metering of several thinner-than-water media into a reactor. Suction lift also was required at low rpm.

Several Eco GEARCHEM pumps with Vickers variable speed drives were employed with Rotometers, permitting accurate adjustment of flow rates of each media. The pumps were equipped with TEFLON† gears and floating wear plates, compensating for expansion and contraction and normal end wear of the TEFLON gears. This construction assures sustained high vacuum for necessary suction lift and reproducible accuracy in constant flow metering within plus or minus one per cent.

Battery Builders Choose ALL-CHEM

DELCO-REMY, Division of General Motors, Anderson, Indiana, long time users of Eco ALL-CHEM Pumps for their non-segmentated, non-aerated flows in handling mixtures of phenol, sulphuric acid and water — have recently reordered for their Olathe, Kansas operation. These ALL-CHEM Pumps are made of Carpenter 20 stainless steel with du Pont TEFLON Impellers, bearings and packings.



Immersion Techniques Provide Ultimate Seal

Nothing better illustrates low cost engineering for ultimate requirements with Eco Pumps than the five GEARCHEM units shown above. This is a repeat order from a customer that has used Eco GEARCHEM Pumps, submerged in an inert liquid, to pump against vacuums in the 20 to 50 micron range in the distillation of aromatics.

Immersion techniques meet operational requirements impossible to accomplish with packed stuffing boxes or even the most complicated mechanical seals. They accomplish not only positive exclusion of air from the pumped media, but also safe disposal of hazardous stuffing box leakage into a suitable immersion medium.

High Praise for Zirconium Pump

Typical of many highly favorable comments from users of Eco zirconium GEARCHEM Pumps are the two following:

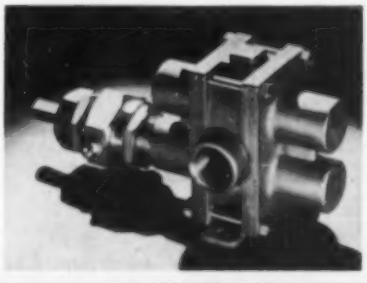
Coast Manufacturing & Supply Co., Livermore, Cal.: "You will probably be interested in knowing that before we installed our Eco pump, we tried two other makes of acid pumps and both failed.

"Our Eco Series 400 GEARCHEM Pump with zirconium body and TEFLON gears has, to date, given us trouble-free, dependable service." (Put in service February 1959, pumping muriatic acid.)

Stauffer Chemical Co. This company reports many disappointing experiences with various makes of pumps to handle methyl sulphonyl chloride until they finally settled on Eco zirconium GEARCHEM Pumps for this problem job. Gears supplied were of TEFLON and shafts of Tantalum.

Petroleum Alkylation Employs Many Monel Pumps

Several refineries have purchased Eco GEARCHEM Pumps in Monel, with carbon bearings and carbon wear plates, metallic gears of Hastelloy C, and grease-sealed, lanterning stuffing boxes. These pumps are handling mixtures of hydrocarbons with hydrofluoric acid in various concentrations and viscosities at pressures to 100 psi and temperatures to 300° F.



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Computer abstracts

from page 86

Smoker distillation program (037)

G. E. Jones, Jr.
Research Department
Koppers Company, Inc.
Verona, Pennsylvania

Description: Program calculates a material balance, internal flows, theoretical stages at several reflux ratios, minimum stages and minimum reflux for an ideal binary system. Sensible heat effects are neglected and equi-molal latent heats are assumed. The equations used are presented in G. G. Brown *Unit Operations,* 1st Ed, John Wiley & Sons, New York (1959) pp 370-372 as modifications on those of E. H. Smoker, *Trans Am. Inst. Chem. Engr., 34,* No. 2, pp 165-72, April, 1938.

Computer: IBM 650

Program language: SOAP II, SIR

Running time: Twenty seconds for each different finite reflux ratio required within a problem plus 10 seconds for initial and terminal calculation for a problem.

Comments: Several successive problems may be solved without the program being reloaded or the computer restarted manually.

Availability: A manual will be prepared if sufficient interest develops.

Machine Computation Committee
A.I.Ch.E.
25 West 45th Street
New York 36, New York

I am interested in computer program manuals corresponding to the following abstracts:

- ☐ **(012) Equilibrium flash vaporization**
- ☐ **(035) Equilibrium flash distillation**
- ☐ **(037) Smoker distillation program**

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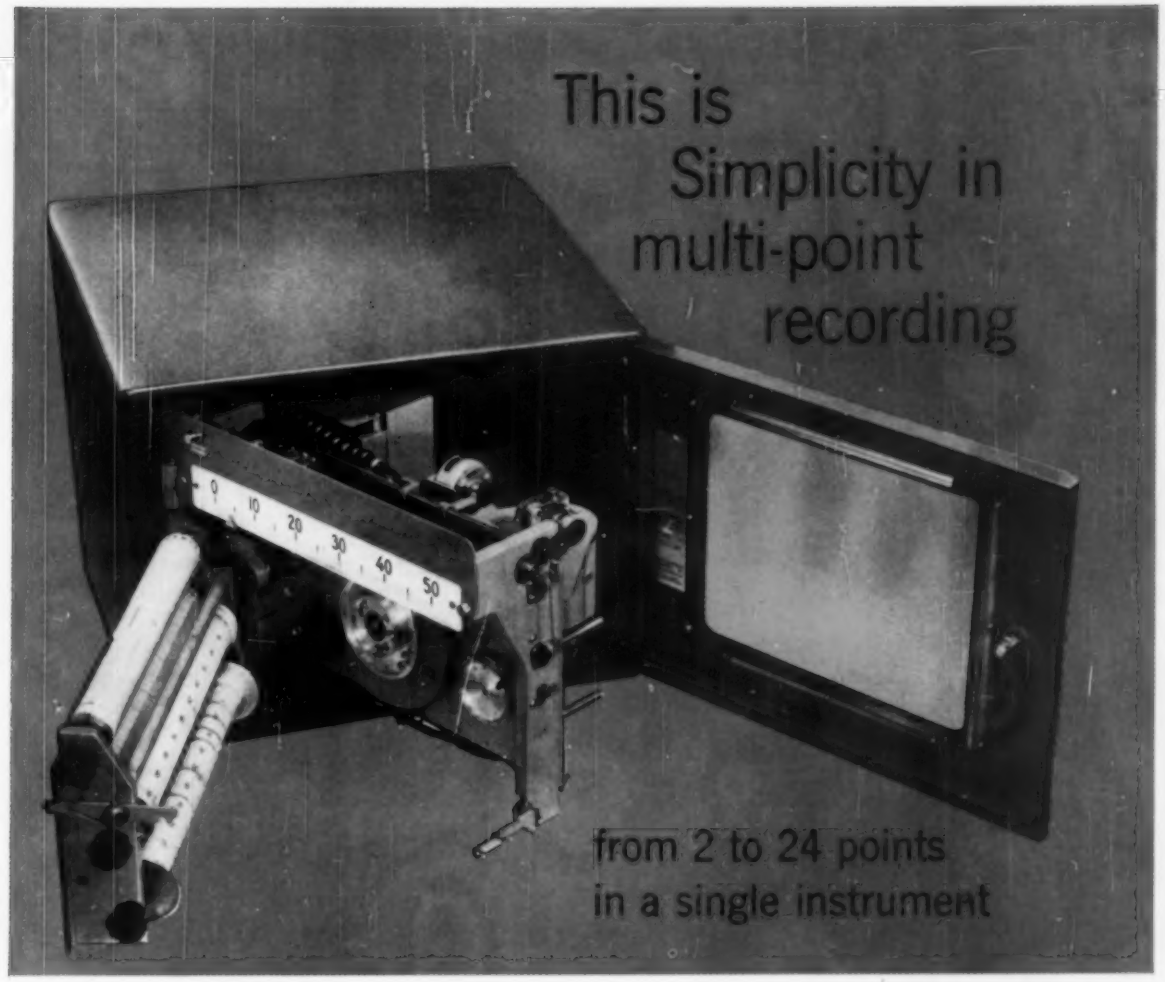

Simplicity is the keynote in the new Daystrom-Weston Model 6702 multi-point recorder – simplicity in both design and performance.

Open the door and you see the advantages of the Daystrom-Weston famous *unitized design* – no jungle of wires, no hard-to-get-at areas . . . every component related in the simplest, most serviceable, most efficient way.

Interchangeability is easier than ever – from one number of points to another . . . one range to another . . . one chart speed to another. You need only a change plug and *newly-combined* station indicator and printing wheel – two units instead of three.

The remarkable Daystrom-Weston D-PAK®, solid state Constant Current Source, eliminates batteries, standard cells, standardizing mechanisms . . . and their maintenance!

You also get all the advantages of the full Daystrom-Weston potentiometer line – long-term reliability . . . high resistance to shock and vibration . . . maximum flexibility (recorder-controller "packages", including panels and accessories, can be suited to your specific application).

You get all this, yet a single instrument handling from 2 to 24 points costs 15% less than the average multi-point! And it can readily be converted to a single-point, curve-drawing instrument by means of a pen accessory.

For further information, contact your local Weston representative . . . or write to Daystrom-Weston Sales Division, Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

DAYSTROM-WESTON INDUSTRIAL INSTRUMENTS include a full line of recording and controlling potentiometers with strip and circular charts; mechanical recorders and indicators for pressure, temperature and flow; and non-indicating controllers, both electric and pneumatic.

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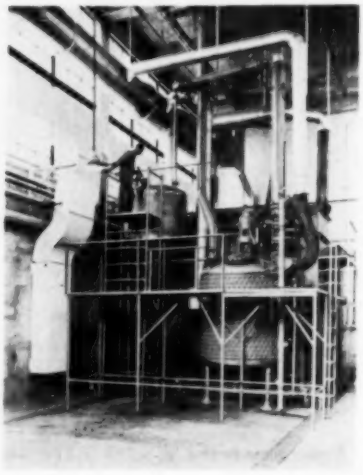
For more information, turn to Data Service card, circle No. 8

industrial news

Base price of Du Pont's Teflon has been cut nearly one-half, bringing it down from $29 to $15 a pound. Start of commercial production, and a price drop in resin used in production of the fluorocarbon film brought about the cut. Applications are in the field of corrosion resistant pipe, containers, and production equipment.

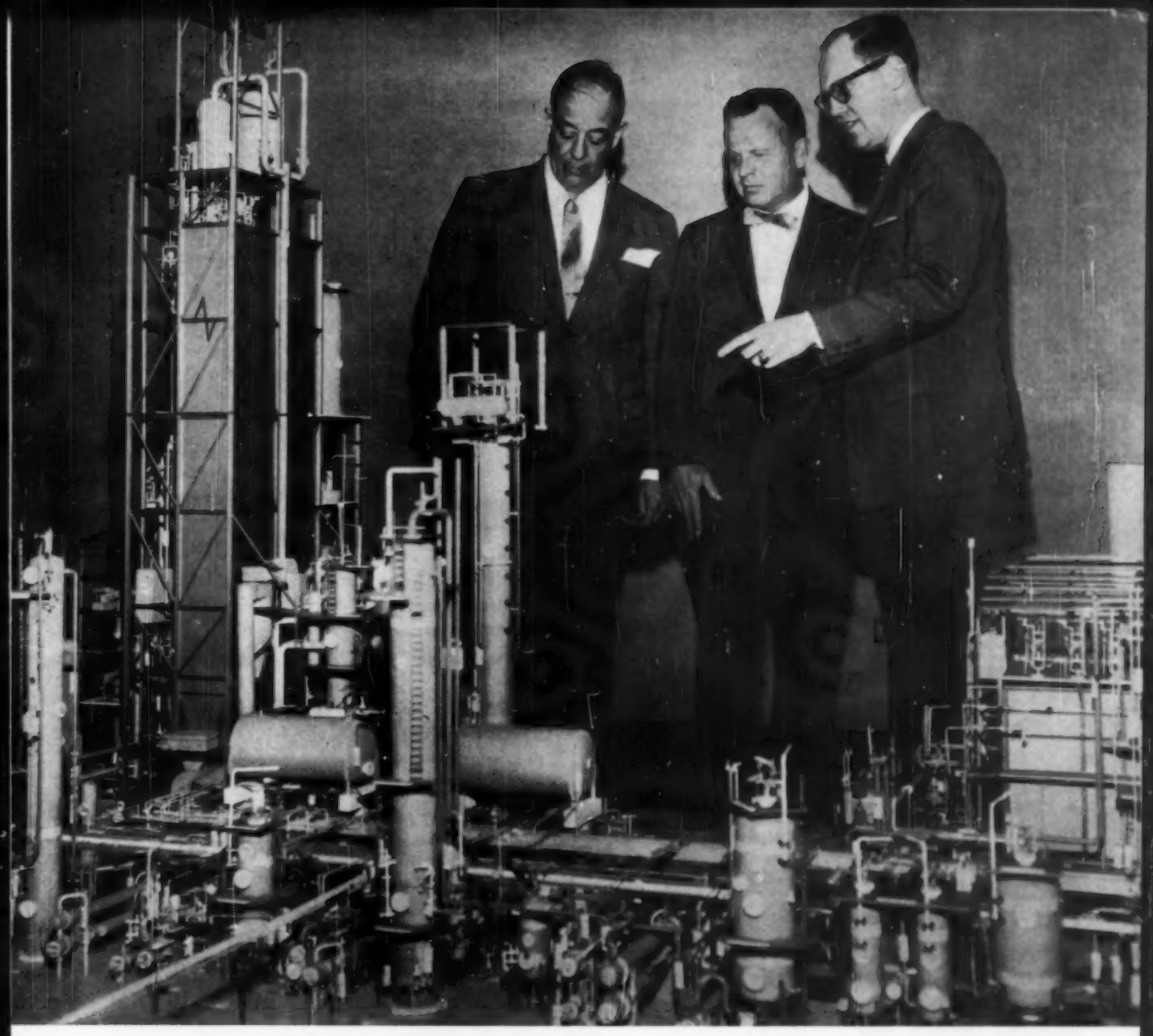
First step in the chemical complex of Dixon Chemical at Paulsboro, New Jersey, a 300,000 ton a year sulfuric acid plant, went on stream last month. The plant will produce sulfuric acid from acid-bearing sludge obtained from oil refining processes, will also produce acid from dry or molten sulfur.



One of five new reactor units recently installed at Udylite's Research Center in Detroit. The autoclave, used to run chemical reactions at over atmospheric pressure, holds 1500 gallons of fluid up to 75 psi. Housed in a 2100 square foot reinforced concrete room, the reactor is part of the $600,000 new company facilities for manufacture of organic chemicals used in metal finishing.

An agricultural chemicals facility now under construction at Richmond, California, by Stauffer Chemical, will replace the company's agricultural chemicals unit at Berkeley. The unit, when integrated with the sulfuric acid and fertilizer production plant at Richmond, will more than double the firm's capacity to produce both dry and liquids for the northern California market.

On a ten acre tract adjacent to the Richmond site, a major research center is also planned. Construction on the first unit starts next year, is due for completion in early 1961.



SEEING IS SAVING...

One important advantage of plant models is that managements can fully exercise their judgment and experience in approving design and layout *before* construction starts.

Here, SunOlin Chemical Company vice-president S. S. Johnson and president James I. Harper are shown reviewing, with Kellogg project manager Robert Jacks, details of their new 200 ton/day urea plant—now being built by Kellogg, using the Fauser-Montecatini Process.

For SunOlin, as for many Kellogg clients, scale models have proved to be an unequalled communications tool for management . . . a superior design tool for engineers . . . a modern construction tool for field workers . . . a sure way, in every way, to minimize man-hours and materials.

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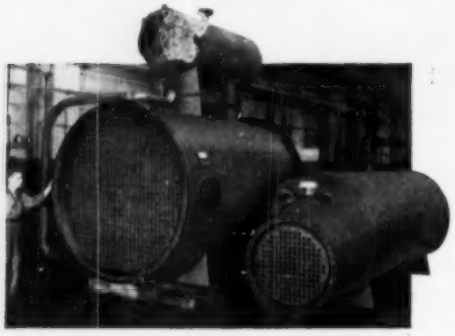
1 A nitric acid plant installed this unit. It has a built-in platinum catalyst chamber.

5 TYPES OF *Waste Heat* STEAM GENERATORS



2 A methanol plant operates these horizontal type units.

Each of the units shown were custom designed to solve the specific problems peculiar to individual plant processes.

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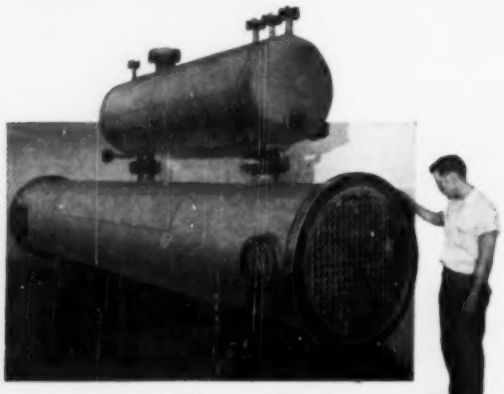
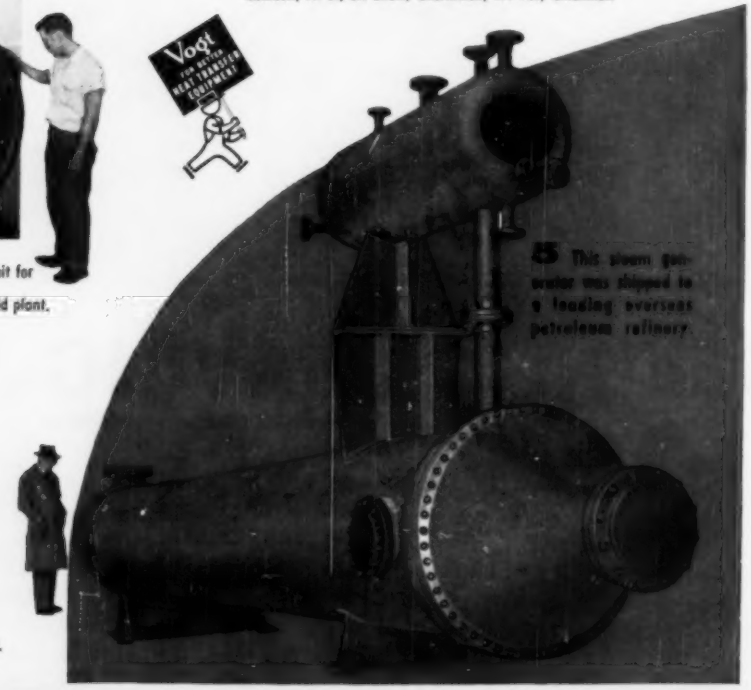


3 Horizontal unit for a nitric acid plant.

4 Vertical type unit for a hydrogen plant.



5 This steam generator was shipped to a leading overseas petroleum refinery.

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Control, level (p. 128). For all types of liquid, horizontal, vertical, external mountings. Info from Jo-Bell Products. **Circle 29.**

Control System, visual (p. 145). Booklet BE-10 from Graphic Systems. **Circle 53.**

Controllers, pressure (p. 126). Bulletin D 4150 A from Fisher Governor gives technical details of the "Wizard II." **Circle 28.**

Cooler, atmospheric (p. 90). Info from Young Radiator. **Circle 38.**

Drums, polyethylene-lined (p. 19-20). Technical info from U. S. Industrial Chemicals. **Circle 107-4.**

Dryers (p. 24). Technical data from C. G. Sargent's Sons on all types for chemical processing. **Circle 46.**

continued on page 94

MATERIALS

Caustic Soda (p. 19-20). Data sheet from U. S. Industrial Chemicals gives specifications, properties, applications, shipping info. **Circle 107-2.**

Coatings, protective (p. 85). Data Book from U. S. Stoneware gives resistance of "Tygon" coatings to over 150 corrosives. **Circle 26.**

Defoamers, silicone (p. 27). Technical data and free samples available from Dow Corning. **Circle 13.**

Gases, compressed (p. 105). Compressed Gas Catalog gives full details of wide range of gases. Matheson. **Circle 42.**

Heat Transfer Fluid (p. 10). Monsanto offers information Booklet on "Aroclor" 1248 heating systems and Guide to Heater Selection. **Circle 52.**

Iron, high-nickel (p. 109). Booklet from International Nickel on "Engineering Properties and Applications of Ni-Resist." **Circle 79.**

Methionine (p. 19-20). Data from U. S. Industrial Chemicals on cosmetic and pharmaceutical use. **Circle 107-1.**

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ERVICES

sign and Construction, process
nts (p. 91). M. W. Kellogg offers
chure on "Planning the New Plant
Profits." **Circle 25.**

rication, process equipment (p.
). Info from Wyatt Metal & Boiler
rks. **Circle 44.**

rication, process equipment (p. 29).
a from Chicago Bridge & Iron on
ks, pressure vessels, etc. made of
rtonclad." **Circle 70.**

rication, process equipment (p. 32-
. Technical data from Dorr-Cliver.
le 75.**

rication, process equipment (p. 36).
tom fabrication for the chemical
cessing industry. Info from Board-
n Co. **Circle 69.**

earch (p. 99). Info from General
tors Research Laboratories on study
the "driver-car-road" complex. **Cir-
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SCELLANEOUS

omobiles (p. 107). Data from Olds-
bile Div., General Motors, on new
ar-differential-variable transformer,
electronic computer for measuring
el alignment. **Circle 87.**

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FREE TECHNICAL LITERATURE

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CEP'S DATA SERVICE—

EQUIPMENT *from page 93*

Dryers, spray (p. 95). Bowen Engi ing offers Test Laboratory Booklet info on feasibility of spray drying. **cle 74.**

Dryers, spray (p. 106). Nichols neering & Research offers data "Nerco-Niro" spray dryers for d of heat-sensitive materials. **Circle**

Drying Systems (p. 7). Info from tor & Schwartz on continuous conv spray, truck, tray, or laboratory t Bulletin 443. **Circle 37.**

Ejectors, jet-vacuum (p. 129). Bul from Jet-Vac gives full technical de of many types. **Circle 50.**

Fans, plastic (p. 28). Wide rang standard sizes in both centrifugal axial designs. Bulletins from Heil ess Equipment. **Circle 10.**

Filters (p. 104). Bulletin SM-1100 Buffalo Filters. **Circle 18.**

Filters, laboratory and pilot-p (p. 31). Data from Eimco on re service for pilot-plant filters. **Circle**

Filter Cloth, metallic (p. 8). All wea all metals, all weights, in rolls or to size. Bulletin F-C from Newark Cloth. **Circle 6.**

Fluid Handling Equipment (p. 1 Pfaudler Permutit offers Buyers G on complete line of services and p ucts. **Circle 108.**

Grinders, fine (p. 123). Info f Gruendler Crusher & Pulverizer on "Super Master." **Circle 78.**

Heat Exchangers (p. 25). Bulletin from Graham Mfg. gives full details the Heliflow heat exchanger. **Circle**

Heat Exchangers (p. 103). Data f Patterson-Kelley on availability of Heat Exchanger Manual. **Circle 2.**

Heat Exchangers (p. 131). Broch M-58 from Puget Sound Fabricat describes facilities for custom fabr tion of heat exchangers, other proce ing equipment. **Circle 17.**

Heat Exchangers, panel-coil (p. 14 Complete data and prices from D Products. **Circle 45.**

Heat Transfer Equipment (p. 26). H Exchanger Bulletin 158-HE from D & Roth. **Circle 83.**

Jet-Venturi Equipment (p. 18). D from Croll-Reynolds on jet refrigerati compressors, condensers, heate pumps, mixers, reactors, absorbe fume scrubbers. **Circle 51.**

Joints, ball, flexible (p. 30). Bulle

215 from Barco Mfg. on flexible ball joints, in sizes from ½ to 16 in. **Circle 5-3.**

Joints, expansion, Teflon (p. 13). Corrosion-proof to all processing fluids except high-temperature fluorine and molten alkali metals. Bulletin B-1A from Resistoflex. **Circle 43.**

Joints, rotary (p. 30). Bulletin 310 from Barco Mfg. gives details of Type C rotary joints for steam, water, hot oil, air, gas, chemicals. **Circle 5-1.**

Joints, swivel (p. 30). Bulletin 265 from Barco Mfg. on self-aligning swivel joints for pressure to 850 lb./sq. in., temperatures to 1,000°F. **Circle 5-2.**

Kettles (p. 131). Standard and custom-built kettles and tanks in stainless, titanium, nickel, Monel, Inconel. Data from Hubbert. **Circle 88.**

Laboratory Ware, fused quartz (p. 125). Complete Catalog from Thermal American Fused Quartz. **Circle 34.**

Meters, pH (p. 121). Bulletin 910-MR describes complete line of pH equipment, including single- and multi-point indicators and recorders. Cambridge Instrument. **Circle 21.**

Mills, grinding, impact (p. 128). For closely controlled particle size reduction, minimum temperature rise. Data from Entoleter Div. of Safety Industries. **Circle 20.**

Mixers (p. 9). Technical info from Simpson Mix-Muller Div., National Engineering on the "Mix-Muller." **Circle 68.**

Mixers (p. 122). For all types of chemical materials. Data from Rapids Machinery. **Circle 101.**

Mixers (p. OBC). Bulletin 109 from Mixing Equipment covers all types. **Circle 80-6.**

Mixers, laboratory and small batch (p. OBC). Bulletin 112 from Mixing Equipment. **Circle 80-5.**

Mixers, portable (p. OBC). ⅛ to 3 hp. Bulletin 108 from Mixing Equipment. **Circle 80-4.**

Mixers, side-entering (p. OBC). 1 to 25 hp. Bulletin 104 from Mixing Equipment. **Circle 80-3.**

Mixers, top-entering (p. OBC). Propeller types, ¼ to 3 hp. Bulletin 103 from Mixing Equipment. **Circle 80-2.**

Mixers, top- or bottom-entering (p. OBC). Turbine, paddle, and propeller types, 1 to 500 hp. Bulletin 102 from Mixing Equipment. **Circle 80-1.**

Nozzles, spray (p. 136). Catalog 24 from Spraying Systems. **Circle 73.**

Piping, jacketed (p. 121). Catalog 356 from Parks-Cramer details jacketed piping, valves, fittings, in wide range of materials of construction. **Circle 31.**

Processor, thin-film (p. 108). For concentrating, distilling, evaporating, desolventizing, stripping, chemical reactions. Data from Kontro. **Circle 76.**

Pulverizers (p. 126). Bulletin 091 from Sturtevant Mill describes industrial applications of the "Micronizer." **Circle 19.**

Pumps, canned (p. 21). Chempump offers composite curve showing wide range of models and sizes. For temperatures from cryogenic to 1,000°F, pressures from vacuum to 5,000 lb./sq. in. **Circle 77.**

Pumps, centrifugal (p. 135). Data from Ingersoll-Rand on complete line for all services and pressures. **Circle 40.**

Pumps, gear (p. 87). Technical data from Eco Engineering on "Gearchem" pumps, available in many materials of construction including titanium. **Circle 24.**

Pumps, gear (p. 88). Horizontal or vertical models to handle 32 to 500,000 SSU, 1 to 550 gal./min., at 50 lb./sq. in. for viscous liquids, 50 lb./sq. in. for water. Bulletin G-2 from Sier-Bath & Pump. **Circle 32.**

Pumps, metering (p. 34). Bulletin 500-A from Lapp Insulator gives complete specifications of the "Auto-Pneumatic Microflo Pulsafeeder." **Circle 71.**

Pump, metering, small (p. IBC). Complete details in Bulletin 1257-1 from Milton Roy. **Circle 30.**

Pump, peristaltic-action (p. 136). For laboratory use. No stuffing box, no shaft seals, non-contaminating. Data and prices from Sigmamotor. **Circle 12.**

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MATERIALS *from page 93*

Organometallics (p. 19-20). Data from U. S. Industrial Chemicals on ruthenocene and osmocene, reported to behave like aromatics. **Circle 107-3.**

Solvents (p. 97). "Solvent Selector" from Union Carbide Chemicals lists 69 solvents, couplers, and diluents, plus several plasticizers. **Circle 72.**

Titanium (p. 19-20). Data from U. S. Industrial Chemicals on fabrication of large titanium ingots. **Circle 107-5.**

FACTS FIGURES AND IDEAS FROM BOWEN ENGINEERING, INC.

Spray drying NEWS

RECOGNIZED LEADER IN SPRAY DRYING SINCE 1926

VOLUME 2, NO. 1

Lignosol meets growing demand for lignosulphonates with new fifty-ton per day spray dryer

EXPECT TO WRITE-OFF INVESTMENT IN THREE YEARS

March 1959 was a notable month in the history of young, pioneering Lignosol Chemicals Limited, Quebec, Canada. It was the month a 100,000-pound per day Bowen spray dryer went onstream to more than double Lignosol's production capacity for some dozen different lignosulphonate products made from pulp mill spent sulphite liquor. Surging demand for these products—used as dispersants, additives and binders in many industries—led to this expansion and clearly justified Lignosol's faith that a profitable, new industry could be built around what was once a troublesome, hard-to-dispose-of waste material.

Prior to installing the Bowen 50-ton unit, Lignosol's capacity totaled 30 tons per day with two smaller spray dryers of another manufacturer. However, in evaluating spray dryer designs for their expansion program, Lignosol chose Bowen equipment for compelling reasons:

FLAT-BOTTOM DESIGN ADVANTAGEOUS—While most manufacturers only supply spray dryers of conical-bottom design, Bowen has had many years of experience with dryers of flat-bottom design as well. In Lignosol's case, a flat-bottom unit was recommended and selected because a conical-type dryer of equal capacity would have required a higher, more expensive building. Also, the flat-bottom feature meant easier accessibility and enabled faster cleaning between production runs of the various products. In addition, it permitted the use of Bowen's patented cold air sweeper technique as an important safety factor in drying some of the highly heat-sensitive Lignosol materials.

LARGER, MORE UNIFORM PARTICLES—Processing starts with piped-in spent sulphite liquor being converted as required to ammonium or sodium base to form a variety of lignosulphonates. Concentrates of 50% to 55% solids are produced by evaporation. Other process steps follow to provide desired product specifications, the proper physical characteristics of which are achieved by spray drying. With their new Bowen unit, Lignosol secures larger, more uniform spherical particles than heretofore—consequently enjoys the advantage of considerably less dusty finished products.

PRODUCT RECOVERY OVER 99%—Controlled atomization of lignosulphonate feed materials in the Bowen dryer is accomplished by a Bowen Spray Machine with a multi-vaned atomizer wheel spinning at 12,000 rpm. Drying air inlet temperatures are in the range of 400° to 500°F. Residence time in the dryer is a matter of seconds and product exit temperature, after air sweeper cooling, is about 140°F. Product collection is carried out with two cyclone collectors followed in series by two tube-type collectors. Recovery is better than 99 percent.

For more information on Lignosol's installation, request Editorial Reprint LC.

Controls for 24-foot diameter Bowen flat-bottom spray dryer are on one centrally-located panel. Note convenient access door at base of dryer.

SPEAKING FOR BOWEN . . .

EARL AMTHAUER, ***Manager of the Bowen Technical Service Dept.,*** **answers some key questions about technical service.**

Q: What technical service does Bowen provide at the time of spray dryer start-up?

A: Before any new Bowen spray dryer installation goes into operation, a Bowen Technical Service Engineer makes an item-by-item check of the complete installation. Then, he personally supervises start-up, makes certain the product produced meets specifications and thoroughly trains plant personnel to operate the new equipment.

Q: Does Bowen Technical Service stop there?

A: Not by a long shot! Our follow-up services contribute a great deal to the fine reputation Bowen spray dryers have for dependable operation. We make a special point of keeping up to date on the performance of our equiment in customer plants. One of the most gratifying parts of my job is to help a customer improve the efficiency of his operation by acquainting him with the latest spray drying techniques—or help him adapt his equipment to meet changing process and product requirements. Incidentally, services of this kind are available to anyone with a spray dryer installation, whether of Bowen design or not.

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 94*

Recorder, multiple (p. 89). Data from Daystrom-Weston on Model 670 Miltipoint recorder. **Circle 8.**

Rectifiers (p. 118). Sel-Rex offers Guide to Industrial Rectifier Equipment. **Circle 33.**

Rotameter, armored (p. 120). Bulletin 19A from Schutte and Koerting gives details of SK Metal-Tube Rotameters. **Circle 47.**

Rotameter-Transmitter (p. 123). Design Specification Sheet from Brooks Rotameter gives full details. **Circle 9.**

Screeners (p. 127). Complete technical details from J. M. Lehmann on the "Vorti-Siv." **Circle 82.**

Separators, entrainment (p. 4). Technical Reprint 591 and Bulletin 21 from Otto H. York describe application of the "Demister" to distillation equipment, vacuum towers, scrubbers, evaporators. **Circle 81.**

Sifter, rotary (p. 5). For single or multiple separations, down to 325 mesh. Bulletin 503 from B. F. Gump on the "Bar-Nun" sifter. **Circle 49.**

Steam Generators, waste heat (p. 92). Data from Henry Vogt Machine Co. on several types of equipment to provide low-cost steam from process heat. **Circle 7.**

Tanks, rubber-lined (p. 108). Complete technical data from Gates Rubber Co. **Circle 39.**

Thermocouple Wells, drilled (p. 119). In any alloy for pressures to 3,000 lb./sq. in. Bulletin 2000 from Claud S. Gordon gives specifications, sizes, ordering info. **Circle 48.**

Tubing, Teflon (p. 118). Chemically inert, abrasion-resistant, stays flexible at extreme temperatures. Info from L. Frank Markel & Sons. **Circle 1.**

Valves, ball plug (p. 11). Catalog from Hydril. **Circle 99.**

Valves, "Flo-Ball." (p. 38). One-piece ball and stem, replaceable seats. In all materials and sizes through 10 in. Data from Hydromatics. **Circle 100.**

Vibrator, bin (p. 129). Prevents bin overflow, conveyor clog, elevator chokeup, machinery damage. Catalog BD-15 from Bin-Dicator. **Circle 15.**

SUBJECT GUIDE to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT

301 Air Processing Equipment. Bulletin S-5 from J. O. Ross Engineering Div., Midland-Ross, gives technical data on ovens, air heaters, curing systems.

302 Blender, glassed-steel. Available in 4, 30, 60, 100, and 250 cu. ft. working capacities. Data on the "Chemo-Blender" from Pfaudler.

303 Castings, high-alloy. New 20-page Bulletin from Duraloy covers static castings, centrifugal castings, shell molded castings. Corrosion data, standard designation and stress-temperature curves.

304 Centrifuge, all-hermetic. For clarification of viscous or inflammable materials, or materials which must be kept from contact with air. Capacity 5,000 gal./hr., pressure to 125 lb./sq. in. De Laval Separator.

305 Centrifuges, conical-screen. Engineering info from Sharples on new line, available in 4 sizes, capacities up to 70 tons/hr.

306 Compressors, packaged. Bulletin 91 from Cooper-Bessemer describes construction and operating features of AM/2 and AM/4 packaged compressors for gas gathering.

307 Computers, analog. New Brochure

continued on page 98

MATERIALS

360 Amine. Technical Bulletin from Du Pont gives complete info on new low-cost, nonvolatile aliphatic amine mixture, called Amine 248.

361 Cationic Chemicals. Booklet from Armour Industrial Chemical covers nine chemicals and new formulations for conditioning fertilizers and salts, gives methods of application and recommended uses.

362 Coatings, protective. New 38-page Catalog from Rust-Oleum Corp. is comprehensive treatise on rust and corrosion control by protective coatings.

363 Cryogenic Fluids. Folding pocket card gives boiling and melting points, critical temperatures, volume, mass, and thermal equivalents, conversion factors. Linde (Union Carbide).

364 1, 4 Dichloro-2-butene (DCB). Technical Bulletin from Du Pont gives handling instruction, data on many reactions of new intermediate.

365 Fatty Acids. New Basic Technical Booklet from Hercules Powder gives properties, uses of fatty acids from tall oil, discusses uses in protective coatings, core oils, flotation, plasticizers, etc.

366 Fluids, functional. Monsanto offers

continued on page 98

SERVICES

377 Cooling Water Treatment Systems. Betz Laboratory, consultants on industrial water problems, offers Data Sheet titled "A Modern Approach to Cooling Water Treatment."

378 Fabrication, processing equipment. Brochure from Troy Div., Skinner Engine, describes "Duplex Disperser," angular mixers, three-roller mills, colloid mills.

379 Fabrication, process equipment. Bulletin 1127 from Goslin-Birmingham covers filters, evaporators, flakers, heat exchangers, condensers, contract manufacturing services.

380 Nuclear Energy Papers. Data from United Nations on the Proceedings of the Second International Conference on Peaceful Uses of Atomic Energy.

381 Research and Development Services. Booklet from M. W. Kellogg describes its comprehensive research and development services now offered on cooperative basis.

382 Scaling-up Methods. Sprout, Waldron offers series of case studies on scaling up of process equipment. Bulletin I-64.

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The wide choice of CARBIDE solvents—esters, ketones, alcohols and glycol ethers—means you can take advantage of blending to obtain the best balance between cost and performance. But the biggest advantage to you is money saved by ordering compartment tank car or tank wagon shipments compared with drum lots. *Estimate for yourself, at a few cents a pound, how much* CARBIDE *solvents can save your company.*

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If you are evaluating solvents to improve your formulations and lower your costs be sure and talk to a CARBIDE Technical Representative. Write for a copy of CARBIDE's "Solvent Selector." This valuable reference lists 69 solvents, couplers, and diluents, as well as a number of plasticizers. It gives evaporation rates, viscosities, flash points, blush resistance, and other data in convenient tabular form. Write for a copy to Dept. HEP., Union Carbide Chemicals Company, 30 East 42nd St., New York 17, N. Y.

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CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 96*

from Computer Systems describes complete line of general and special purpose analog computers and accessories.

308 Controls. New 72-page Catalog from General Electric gives technical data on complete line of control devices. Features, wiring diagrams, dimensions, application info.

309 Control instruments. Data Sheet from Leeds & Northrup gives full details of "Speedomax" indicators, recorders, controllers, for pH and redox. Includes wire diagrams for installation.

310 Controller, electronic. Technical data and prices from Edwin L. Wiegand on new type PC "Chromatrol" electronic controller. Accuracy within 1% up to 600°F.

311 Conveyors, spiral. New 56-page Catalog 951 from Jeffrey Mfg. gives engineering data, conveyor layouts, capacity tables, selection data, horsepower requirements. Many drawings and tables.

312 Cryogenic Equipment. New 16-page Bulletin from Standard Steel describes complete line of cryogenic equipment to store, handle, transport low-temperature liquid gases.

314 Dehydration Units. Bulletin from J. F. Pritchard describes the "Hydryer," packaged dehydration unit for reducing the moisture content of gases or liquids to very low levels.

315 De-Sludgers. New Booklet from Centrico gives detailed description of design and operating principles of complete line of automatic de-sludgers.

316 Dryers, air. Bulletin from Bryant Mfg. describes air dryers for humidity control and industrial process drying. Package units available in 7 sizes.

317 Dryer-Cooler. Bulletin D959 from Edw. Renneburg & Sons describes applications of the "DehydrO-Mat." Schematic drawing, engineering details.

318 Dryers, Coolers. Comprehensive 32-page Book from Jeffrey Mfg. covers electric and mechanical vibrating-type coolers and dryers of both direct and indirect type. Many drawings, specifications, material weight charts.

319 Elevators, cable-type. Brochure from Hapman Corp. describes the "Hi-Lift Cable-Veyor." Dimensional installation drawings.

320 Equipment, plastic. Heil Process Equipment offers Bulletin B-500 on ventilation products, plastic tanks.

321 Evaporator-Stripper. New mass transfer device features low hold-up time, low pressure drop, good efficiency, film-type evaporation for heat-sensitive materials. Info from Artisan Industries.

322 Filter, high-pressure, rotary leaf. Data from Buffalo Filters on large high-pressure filter built recently for polymer service.

323 Filter Cloths. Wheelabrator offers handy comparison chart as guide to selection of filter cloths commonly used in dust and fume collectors.

324 Flowmeter, high capacity. Design Specification Sheet DS-132 from Brooks Rotameter gives materials of construction, capacities, ratings.

325 Heat Exchangers, graphite, immersion-type. New 12-page Catalog Section S-6620 from National Carbon covers impervious graphite heat exchangers and circulating steam jets. Many nomographs and curves.

326 Heat Exchangers, Pyrex. Corning Glass introduces new standard and regenerative Pyrex shell and tube exchangers with 60 sq. ft. capacity. Technical details.

DEVELOPMENT OF THE MONTH

MULTI-STAGE CENTRIFUGAL

(Circle 602 on Data Post Card).

A new multi-stage, push-type centrifugal, developed by Escher-Wyss, Zurich, Switzerland, is being offered in the United States by Baker Perkins. The new-type unit is designed to handle materials which are difficult to process in single-stage machines.

The separate stages, or baskets, are telescoped into another. They are connected to the hub and pusher mechanism in such a manner that the basket section, which is stationary in the axial sense, is followed by a basket receiving lateral motion from the pusher. As a consequence, the end of each basket serves as a pusher for the following stage.

Power consumption is said to be less than that of single-stage machines, since push pressure is utilized on both forward and return strokes, which results in a more constant power demand.

For a Technical Bulletin from Baker Perkins with all engineering details, Circle 602 on Data Post Card.

327 Heaters, sludge. Bulletin 1001 from Ralph B. Carter describes new forced-counterflow, tube-within-tube sludge heater and heat exchanger units. Principles of operation, design and construction features, performance and dimension data.

328 Instrumentation, nuclear. Catalog 59 from Nucleonic Corp. of America lists complete line of nuclear instrumentation and technical services.

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MATERIALS *from page 96*

chart summarizing general properties of wide range of functional fluids, including "Aroclor" heat transfer medium.

367 Fluorinated Hydrocarbons. Pennsalt Chemicals offers brochure on blowing urethane foams with fluorinated hydrocarbons.

368 Glass, corrosion-resistant. Data from Glascote (A. O. Smith) gives complete details on new glass, said to be most corrosion-resistant ever applied to steel products.

369 Molecular Sieves. Brochure from Linde (Union Carbide) titled "Chemical-Loaded Molecular Sieves in Rubber and Plastics." Info on testing, handling, etc.

370 Organic Chemicals. Union Carbide Chemicals offers new 28-page Physical Properties Booklet describing more than 400 synthetic organic chemicals. Applications, physical properties, shipping data.

371 Plasticizers. New Catalog L-104 from Eastman Chemical Products describes complete line of plasticizers. Physical and chemical properties, complete specification data.

372 Plasticizer, polymeric. New Bulletin L-103 from Eastman Chemical Products on NP-10 gives performance data on effects of plasticizing PVC with varying amounts, both in plastisol and plastic formulations.

373 Pyridines, Piperazines. New 20-page Booklet from Union Carbide Chemicals gives properties, uses of 5 pyridines, 6 piperazines.

374 Sodium-Potassium Alloys. Technical Bulletin MSAR 59-120 gives chemistry, properties, applications of sodium-potassium alloys and potassium.

375 Surfactants. New 22-page Booklet from General Dyestuff describes applications of IGEPAL surfactants in manufacture of pulp and paper.

376 Titanium. Crucible Steel offers new Brochure "Making the Most of Titanium in the Chemical Process Industries." Extensive corrosion data.

One of a series

Resolving the driver-car-road complex

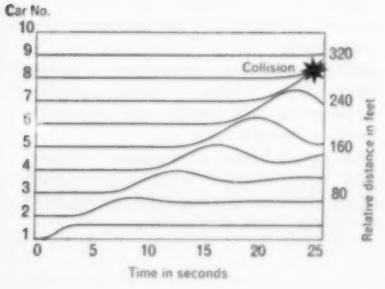
The manner in which vehicles follow each other on a highway is a current subject of theoretical investigation at the General Motors Research Laboratories. These studies in traffic dynamics, coupled with controlled experiments, are leading to new "follow-the-leader" models of vehicle interaction.

For example, conditions have been derived for the stability of a chain of moving vehicles when the velocity of the lead car suddenly changes — a type of perturbation that has caused multiple collisions on modern superhighways. Theoretical analysis shows that the motion of a chain of cars *can be stable* when a driver accelerates in proportion to the relative velocity between his car and the car ahead. The motion is always unstable when the acceleration is proportional only to the relative distance between cars. Experimentally, GM Research scientists found that a driver does react mainly to relative velocity rather than to relative distance, with a sensitivity of reaction that increases with decreasing distance.

Traffic dynamics research such as this is adding to our understanding of intricate traffic problems — what causes them, how they can best be resolved. The study is an example of the ways GM Research works to make transportation of the future more efficient and safe.

General Motors Research Laboratories

Warren, Michigan



Relative positions of 10 hypothetical cars after lead car goes through maneuver. Amplitude of instability increases, resulting in a collision between 7th and 8th cars.

For more information, turn to Data Service card, circle No. 3

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 98*

329 Jet Apparatus. Condensed Bulletin J-1 from Schutte and Koerting describes industrial application of many types of jet apparatus.

330 Joints, flexible. New Bulletin from Resistoflex gives details of Fluoroflex-T flexible joints and bellows, made of Teflon for non-standard low and high temperature and corrosive applications.

331 Laboratory Equipment. Catalog Supplement No. 38 from Scientific Glass Apparatus titled "What's New for the Laboratory."

332 Liquid Processing Equipment. Bulletin from Alsop Engineering gives engineering data, specifications of agitators, filter media, filters, mixers, pumps, tanks, special units.

333 Ovens, laboratory. Data from Despatch Oven Co. on new rotary-shelf laboratory oven. Available with either manual or mechanical operation.

334 Piping, plastic. New 36-page Handbook for engineers contains detailed info on use of PVC plastic pipe, fittings, valves. Corrosion resistance comparison chart for 7 types of plastic pipe, 162 chemicals. Kraloy Plastic Pipe Co.

335 Porous Metal. Technical Brochure BFD-141 describes "Poroloy" wound wire porous metal for filtration and non-filtration applications. Specifications and curves for flow rate and physical characteristics. Bendix Filter Division.

336 Pumps, canned. Bulletin 1020-2 from Chempump gives specifications, description, typical performance curve for Series DE multi-stage, sealless canned pumps for heads to 220 ft.

337 Pumps, centrifugal, leakproof. Info from Sethco Mfg. on new type of centrifugal pump designed for transferring corrosive liquids and solvents without leakage. Maximum rate 20 gal./min., pressures to 150 lb./sq. in.

338 Pump, diaphragm-type. Data from B-I-F Industries on the "Chem-O-Feeder" for accurate proportioning of concentrated corrosive chemicals. Capacities to 0.7 gal./hr., discharge pressures to 100 lb./sq. in.

339 Pumps, high-vacuum. Bulletin 8-20 from Consolidated Vacuum gives operating characteristics, engineering data.

340 Pump, metering. Bulletin from Associated Control Equipment lists capacities, operating characteristics, stroking rate, materials of construction, power requirements.

341 Pumps, metering. Bulletin 530 from Lapp Insulator contains table with capacities, sizes, applications on four basic "Pulsafeeder" automatic metering chemical pumps.

DEVELOPMENT OF THE MONTH

GIANT TWIN-SHELL BLENDER

(Circle 601 on Data Post Card).

A giant twin-shell blender, designed and fabricated by Patterson-Kelley, has a working capacity of 1,700 cu. ft., weighs 30 tons. Shells of the unit, each 11 ft. in diameter and more than 22 ft. high, are constructed of solid ½ in. stainless steel (type 304). The blender will be charged and discharged through an air-operated outlet valve at the apex of the V-shaped shells. For complete details, Circle 601 on Data Post Card.

342 Pumps, metering. Bulletin from Wallace & Tiernan gives details of new metering pump line, Series 200. Metering accuracy of plus or minus 1% against pressures to 4,000 lb./sq. in. Performance data.

343 Pumps, transfer. Technical info from Turbocraft describes medium-pressure model for petrochemical and cryogenic service.

344 Pumps, variable-capacity. Bulletin from Blackmer Pump on "Vari-Flo" pumps and proportioning units. Vane-type construction eliminates need for variable-speed drives.

345 Pyrometer-Controller. Bulletin 0035 from Atlantic Pyrometers describes principles of operation, applications to process.

346 Rotameter, transmitting, pneumatic. Bulletin 18N from Schutte and Koerting describes new line of rotameters for air signaling fluid rates of flow to remote-located recorders and controllers.

347 Rupture Disc Assemblies. Catalog from Metal Products gives complete engineering and design info, specifications, selection data.

348 Safety Head Assemblies. Catalog 459 from High Pressure Equipment gives full dimensional data for designs of safety head assemblies.

349 Seal, shaft, Teflon. Shaft sizes from ⅝ to 3 in. Bulletin S-233 from Crane Packing.

350 Telemetering Systems, pulse code. Bulletin CP 3707 from Vapor Recovery Systems describes applications of pulse code telemetering system for remote indication of liquid level, temperature, pressure gauges, etc.

351 Thermocouples, mineral-insulated. Catalog 300 from Conax covers more than 24,000 assembly combinations available from stock. Includes data on hot junctions, terminations, mounting methods.

352 Tubing, pressure, Nylon. Available in continuous lengths from minimum size of .010 by .060 in. to maximum of .280 by .500 in. Info from Garlock Packing.

353 Valves. Technical data from Walworth on new solder-joint, rising-stem, bronze gate valve. In sizes from ⅜ through 3 in., pressures to 125 lb./sq. in.

354 Valves, butterfly, rubber-seat. Bulletin 10AG gives complete specifications, dimension drawings, water flow data, gas flow data, weights, prices. Henry Pratt Co.

355 Valves, butterfly, rubber-seated. Bulletin 5904 from Darling Valve & Mfg. gives info on construction, design, dimensions, materials of construction, operating instructions, ordering.

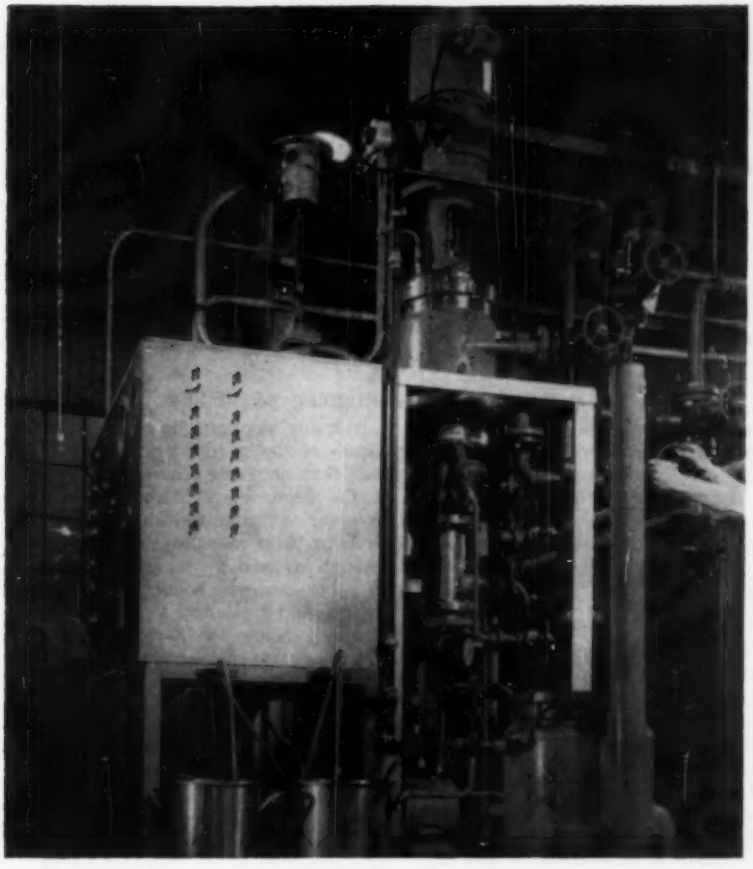
356 Valves, gate, Nylon-disc. Suitable for pressures to 75 lb./sq. in., temperatures to 200°F. Complete engineering info and specifications in Bulletin NP-76-E from OPW Jordan.

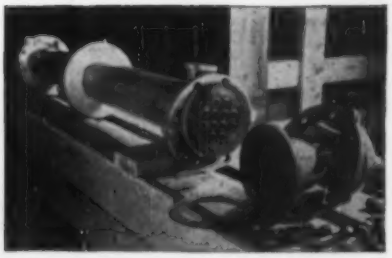
357 Valves, magnetic. For control of water, oil, brine, air, solvents, gas, steam. Bulletin from Magnetrol Valve.

358 Valve, slurry. Bulletin from Everlasting Valve describes new type of quick-acting slurry valve, available in 3, 4, and 6 in. sizes.

359 Valves, solenoid. Selection Guide and Price List 506 from Automatic Switch Co. lists complete line available for immediate delivery.

FLUIDICS* AT WORK





Why and how to get a combination heat exchanger

Suppose you want to concentrate sulphuric or nitric acid on the tube side, using high pressure steam on the shell side. What kind of heat exchanger would you select?

Faced with this problem, our answer was a *combination*—bonnets of Glasteel, tubes and tube sheet of tantalum, and a shell of carbon steel, as illustrated above.

CHOICE OF MATERIALS. This combining materials of construction is something we are in a unique position to handle. For example, from Pfaudler you can get components made from stainless, GLASTEEL, nickel, Inconel, Monel, Hastelloy, and impervious graphite.

And now you can even get the special characteristics of components fabricated by us from titanium, tantalum, and zirconium.

OPTIMUM DESIGN. The intent of combining materials is to provide the optimum design in terms of heat transfer efficiency and corrosion resistance at the *lowest cost*.

Since our background and facilities cover this wide choice, you are sure that your needs are met with complete objectivity. Your product, your process, and your budget will point the way.

YOU'RE INVITED. What it ends up with is this invitation: Consult with us on your problem. We will then submit our recommendation on the right combination. Or get more background from our Bulletin No. 949.

BUYERS' GUIDE. Outlines our FLUIDICS program in terms of services and products for corrosioneering, water treatment, storage, agitation, etc. Send for your free copy.

Facts about the WIPED FILM evaporator

Difficult evaporations include (1) heat-sensitive, (2) highly viscous and (3) low-thermal-conductivity products. The Pfaudler Wiped Film Evaporator is designed for use with such products.

One of its unique features is a *mechanically wiped* evaporating surface.

How it operates

Centrifugal force of an internal rotor holds four free-floating wipers in contact with the evaporator wall. Wipers spread out your product over the entire evaporating surface in a *thin uniform* film. Slots in each wiper prevent product "curl" forward of the wipers and accelerate product down the wall.

Complete wetting of the heated wall achieves maximum heat transfer.

Low rotor speeds (90-120 rpm) provide sufficient centrifugal force for positive wiper contact.

Features

- Wipers assure short contact time on heated surface for sensitive materials.
- Moves even viscous liquids easily through unit.
- Promotes formation of a thin film for efficient heat transfer on low-thermal-conductivity products.

Test and Production Units

A 4-square-foot Wiped Film Evaporator is maintained in the Pfaudler Test Center for product evaluation studies.

Standard units available offer 4 to 100 square feet of evaporating area.

For further specifications or for details of a test program, write our Pfaudler Division, Dept. CEP-10, Rochester 3, New York.

FLUIDICS AROUND THE WORLD

Pfaudler Permutit is a world-wide company with manufacturing plants in:
Germany: Pfaudler-Werke A.G.
Great Britain: Enamelled Metal Products Corp. Ltd.
Canada: Ideal Welding Co. Ltd.
Mexico: Arteacero-Pfaudler, S.A.
Japan: Shinko-Pfaudler Co., Ltd.
as well as four plants in the U.S.A.

PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS . . . the science of fluid processes

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

For more information, turn to Data Service card, circle No. 108

industrial news

Atomized suspension speeds reactions

New hot-wall tower technique seen applicable to many chemical processing operations.

NEW APPLICATION VISTAS are rapidly opening out for a novel processing technique, originally aimed exclusively at recovery of chemicals from pulpmill spent liquors. Atomized Suspension Technique, as the new method has been christened by its inventor, W. H. Gauvin, head of the Chemical Engineering Division of the Pulp and Paper Research Institute of Canada, in Montreal, differs from its cousin, conventional spray drying, in that no carrier or drying gas is introduced into the reactor, and in that no film of gas is adsorbed on the surface of the particles.

High wall temperature

An AST reactor is nothing more or less than an empty tower whose wall is maintained at a relatively high temperature. When a slurry or a solution is atomized into it, the moisture of the droplets flashes into superheated steam. This steam becomes the carrier vapor, as the evaporating droplets move down the tower. Part way down the tower, all the moisture has been converted to steam, and the solid particles are suspended in an essentially non-turbulent vapor of their own creation. As this suspension continues down the reactor, various kinds of physical and chemical reactions can be induced consecutively, in the space of a few seconds. For example, if the solids are organic material, introduction of a small amount of air will bring about complete combustion.

First commercial application

Pulp mill application of the new process, under pilot-plant development since 1952, has not yet been completely de-bugged, despite expenditures of close to a million dollars by the pulp and paper industry. However, at Beaconsfield, Quebec, AST has been successfully applied to the disposal of sanitary sludges. Here, it replaces conventional bacterial digestion and drying of the settled raw solids by a method which burns the material to a harmless inorganic ash in less than a minute.

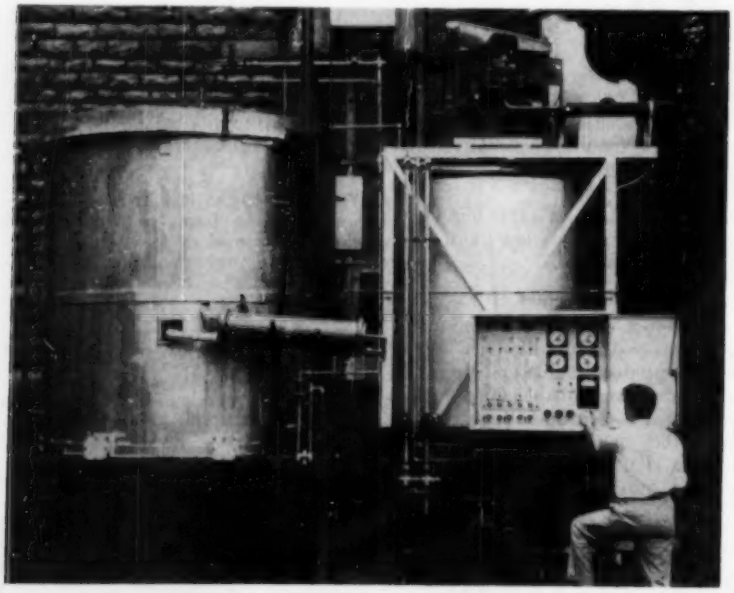
Intriguing possibilities

In many applications of AST, the nature of the solid particles will be such that no gases are evolved even at the high temperatures involved. However, an atomized suspension of these particles may be caused to fall through a catalytic screen to touch off other desired chemical reactions. Or, powdered catalysts may be blown in gently below the drying zone. In addition, gases such as oxygen, hydrogen, or fluorine may be introduced into the AST reactor. These gases will not back-mix up the tower, since there is no turbulence, and will produce the desired chemical reaction as they are carried downward in the non-turbulent suspension. And because the dried particles, dispersed widely in a vapor, have all their surface exposed to heat transfer and chemical reaction, the reactions induced can be expected to be rapid.

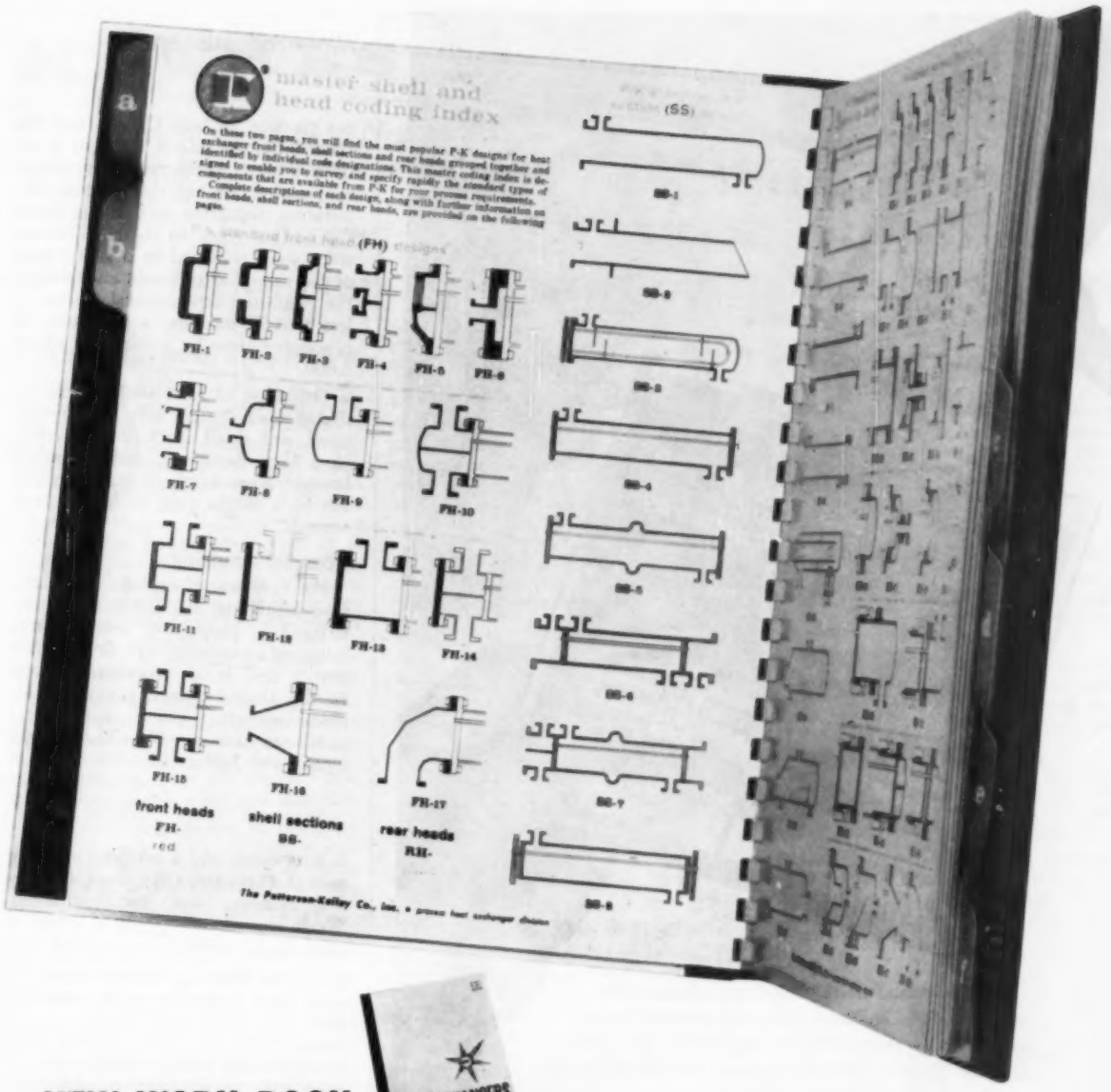
Researched in the Institute's labs have been such processes as:

- Extraction of sulfur dioxide from spray-dried calcium-base waste sulfite liquor from a pulpmill. In a fluidized-bed system, the dry particles had to remain in a heated column for 22 minutes to get optimum yield of the sulfur dioxide. In an AST reactor, the liquor was evaporated and dried, and the sulfur dioxide driven off in 7 seconds.
- Roasting of iron pyrites to drive off sulfur in the gaseous state. In commercial practice, the solid particles must remain suspended in a fluidized bed for about 30 minutes, and about 15% of them have to be recycled. In an AST reactor, the same process is said to have been accomplished in 7 seconds.
- Extraction of uranium oxide (U_3O_8) from uranyl nitrate solution. In pres-

continued on page 104



First pilot demonstration plant for AST process, in Montreal, Canada.



NEW WORK BOOK SIMPLIFIES HEAT EXCHANGER SELECTION

The need for a standard terminology to simplify communications between P-K and engineers in the chemical processing industry has been met in P-K's new Heat Exchanger Manual.

This unique communications tool illustrates and describes components of shell and tube heat exchangers commonly used in processing. A complete system of interchangeable front heads, shells and rear heads is established. Fundamentals of heat transfer and design are reviewed. Even economic considerations are discussed. The simple, certain nomenclature saves time, effort and duplication of engineering work.

This 120-page manual, indexed and bound in hard covers, will be supplemented from time to time with new technical material. Names of holders will be registered to receive such material as it appears.

Only a limited number of copies is available and, naturally, these should go to those in the process industries who will benefit most from the information we have compiled. If you design or specify heat exchangers, write us on your company letterhead, outlining briefly areas of your interest. A few copies are available to students and non-technical personnel at a nominal charge. Patterson-Kelley Co. Inc., E. Stroudsburg, Pa.

Patterson Kelley
Heat Exchanger Division

For more information, turn to Data Service card, circle No. 2

Atomized suspension

from page 102

ent practice, in both Canada and the United States, this is done in a sequence of six batch-processing steps: evaporation, drying, dehydration, denitration, reduction to uranium oxide (UO_3), reduction to U_3O_8. These six steps were achieved in a single pass of the uranyl nitrate solution through the Institute's experimental reactor in less that 7 seconds, a reduction of processing time by a factor of about 3,600.

• Oxidation of raw, settled, sanitary sludge. Such sludges have been evaporated and dried, bacteria and odors have been destroyed, and the solids brought down to about 98% inorganic ash in a single pass in less than 5 seconds.

Open for licensing

For commercial exploitation of the new technique, the Institute has developed a pattern of non-exclusive licensing agreements with firms which design and build processing plants. In the United States, companies already operating under such agreements are Lummus, Blaw-Knox, Stolle Corp., and Infilco, Inc.

A fluid coker and a catalytic cracking unit at Tidewater Oil's Avon, California, refinery, was just completed. Work was done by Fluor under a turnaround maintenance contract.

A 50 ton Chemico contact sulphuric acid plant currently under construction at Winnipeg, Canada, will operate with Canadian sulphur. The newly formed Border Chemical Company will convert later to sulphur dioxide gas from the roasting of new Manitoba Mining and Smelting, Ltd. sulphide concentrates.

The manufacture of liquid meters and valves will take place at Pinnesberg, West Germany, under an expansion planned by Rockwell Manufacturing. The addition to the plant was decided upon when a market research program convinced Rockwell that a European and world market existed for liquid meters for petrolum and other liquid product industries. Edward high-pressure, high-temperature valves for power plants will also be made at the West German location.

A multi-million dollar iso-octyl alcohol plant will be constructed at the Gulf Philadelphia refinery of Gulf Oil. Contract goes to Badger.

MATHESON

Compressed Gas Notes

Hydrogen Chloride, Anhydrous, in the Organic Synthesis Laboratory; Flowmeters and Regulators

Hydrogen Chloride, Anhydrous

Hydrogen Chloride has many applications in organic synthesis, some of which are discussed below. When there is a choice between gaseous hydrogen chloride and concentrated aqueous hydrochloric acid in chemical operations, chemists have found that hydrogen chloride offers some distinct advantages over aqueous hydrochloric acid. It is easier to introduce into a reaction because of its high cylinder pressure, thereby eliminating the need for pumps or pressurized carboys, and process operations are simplified.

Applications

(A) For the preparation of hydrochlorides of amines by treating the amine in an appropriate organic solvent with hydrogen chloride under anhydrous conditions. Products can be obtained free from objectionable odor and moisture.

(B) For the preparation of esters by using hydrogen chloride in lieu of sulfuric acid as the catalyst. In some cases, the yield is improved and there is less product damage.

(C) For the preparation of alkyl chlorides by treating an alkanol with hydrogen chloride in the presence of zinc chloride.

(D) For introducing the chloromethyl group (CH2C1) e.g., by introducing hydrogen chloride into a suspension of paraformaldehyde and anhydrous zinc chloride in benzene to obtain benzyl chloride, PhCH2CL. The process may be varied by using methylal or chloromethyl methyl ether in place of paraformaldehyde.

(E) For the preparation of aromatic aldehydes by treating aromatic hydrocarbons with a mixture of carbon monoxide and hydrogen chloride in the presence of a metal halide catalyst.

(F) For the preparation of aromatic aldehydes by passing hydrogen chloride into a suspension of sodium cyanide and aluminum chloride in an excess of the hydrocarbon.

A typical analysis of Matheson's Hydrogen Chloride is as follows:

Hydrogen Chloride	99.3%
Inerts	0.2%
Carbon Dioxide	0.5%

Hydrogen Chloride, as well as more detailed information on its properties, can be obtained by contacting any of Matheson's plants at East Rutherford, N. J., Joliet, Ill., or Newark, California. The gas is readily available in a range of cylinder sizes from a standard 57 lb. #1 cylinder to the 8 oz. Lecture Bottle. Our Compressed Gas Catalog gives full details. Write for your copy.

Corrosion Resistant Regulators

Matheson has a group of regulators and controls which not only will handle Hydrogen Chloride safely, but will also operate efficiently in controlling and/or reducing pressures of Hydrogen Sulfide, Sulfur Dioxide, Boron Trifluoride, and Nitric Oxide, to name a few.

Matheson has developed this type of regulator, see the No. 15 pictured here, by properly employing new corrosion resistant materials that have become available in the last few years. A special plating process is used to coat all surfaces of the regulator, inside and out, with corrosion resistant nickel. The diaphragm and springs are also specially coated. The seat is resilient, inert Kel-F; all gaskets are Teflon. The needle valve on the outlet end is monel. A monel check valve can be supplied too and is recommended for use with the No. 15 series to prevent suck-back of foreign materials into the cylinder.

Specifications are included in the Matheson compressed gas catalog.

This catalog deals with many recent innovations in handling corrosive and inert gases with a complete line of Automatic Pressure Regulators, Safety Devices, Flowmeters, Valves, and Manifolds. The catalog listings of our 82 compressed gases also recommend Matheson controls for every available compressed gas.

Flowmeters for Corrosive Gases

Matheson Flowmeters can be specially fitted to measure the flow of Hydrogen Chloride and other corrosive gases with complete safety.

All of the series 600 flowmeter tubes are made of Pyrex and they are equipped with dual spherical metering floats, one of Pyrex and the other of Stainless Steel.

The Single Tube units, Four Tube units, and the 215 series flowmeters can be made available for corrosive service with corrosion resistant end fittings.

Our new pamphlet, Matheson Laboratory Flowmeters, gives prices and operating specifications for all of our Flowmeters and their accessories.

Any Questions?

Our Technical Department, in East Rutherford, New Jersey, has extensive information on compressed gases and gas handling equipment. We will welcome an opportunity to help solve your problems concerning the use of compressed gas.

The Matheson Company, Inc.

Compressed Gases and Regulators

East Rutherford, N. J.; Joliet, Ill.; Newark, Calif.

For more information, turn to Data Service card, circle No. 42

A.I.Ch.E Candidates

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Campanella, Salvatore, *Syracuse, N. Y.*
Cooley, Kenneth E., *Webster Groves, Mo.*
Crouse, Warren R., *Daly City, Calif.*

Dean, E. J., *Sewickley, Pa.*
Dedert, W. R., *Crete Illinois*
Diehl, John E., *Temple City, Calif.*

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Galstaun, Lionel S., *San Francisco, Calif.*
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Heym, George E., *Baton Rouge, La.*
Hooper Howard C., *Henderson, Nevada*
Huntington, William L., *Philadelphia, Pa.*

James, G. Russell, *Armonk, N. Y.*
Jamison, Howard M., *Pittsburgh, Pa.*

Kleist, Carl, *Cahokia, Ill.*
Klemm, William A., *Permanente, Calif.*

McCleskey, Greer, *Bartlesville, Okla.*
McGee, Omer H., Jr., *Clairton, Pa.*
McGregor, Don W., *Houston, Texas*
McManus, Calvin J., Jr., *New York, N. Y.*
Meer, Frank C., *Seattle, Washington*

Neipert, Marshall P., *Midland, Mich.*

Rinehart, Lyle E., *St. Paul, Minn.*

Senning, Herbert C., *Chicago, Ill.*

Ter Poorten, A. C., *Houston, Texas*
Thompson, James L., Jr., *Claymont, Del.*

Urquiza, M. A., *Kingsport, Tenn.*

Watkins, P. H., *Baton Rouge, La.*
Wenzel, Leonard A., *Bethlehem, Pa.*

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Alfert, Jorge, *Berkeley, Calif.*
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Antia, Jal Merwanji, *Bombay, India*
Arthurs, Marvin J., *New York, N. Y.*

Bailey, Anna, *Brookline, Mass.*
Bara, Andrew Stanley, *Elizabeth, N. J.*
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Cokelet, Giles R., *Williamsburg, Va.*
Cope, Charles S., *Wilmington, Del.*
Corbett, Ronald W., *Ponca City, Okla.*
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Crowe, Cameron M., *Hamilton, Ont., Can.*
Curry, Philip E., *Pensacola, Fla.*

Davis, Wayne T., *Baton Rouge, La.*
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Doane, Elliott P., *Niagara Falls, N. Y.*
Duttweiler, Charles T., *New York, N. Y.*

Ellis, Paul J., *Skokie, Ill.*

Farris, George J., *Fanwood, N. J.*
Fleming, Ronald F., *Ann Arbor, Mich.*
Forsten, Alfred H., *Philadelphia, Pa.*
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French, John K., *Rochester, N. Y.*
Fridley, Dale L., *Baytown, Texas*

Gilmore, John H., *Tarrytown, N. Y.*
Goldberg, Edward S., *North Augusta, S. C.*
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Hauer, Kurt L., *St. Paul, Minn.*
Henderson, Mary Elizabeth, *Huntsville, Ala.*
Hildebrand, Carl E., *Boron, Calif.*
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Hogg, Roger M., *Orangeburg, S. C.*
Holmberg, James E., *St. Paul, Minn.*
Honari, Siyavoush, *Albany, Calif.*
Hooper, Joyce E., *Baton Rouge, La.*
Houston, N. Wayne, *Waverly, Ohio*

Irelan, J. R., *Amarillo, Texas*

Jeffreys, Robert J., *Los Angeles, Calif.*
Jones, Edward M., Jr., *Baton Rouge, La.*

Kessel, James B., *Niagara Falls, N. Y.*
Kieran, William, *Detroit, Mich.*

continued on page 108

A.I.Ch.E Candidates

Klimavicz, John J., *Edgewood, Md.*
Knecht, Roy E., *Florissant, Mo.*

Lawroski, Harry, *Idaho Falls, Idaho*
Levander, Carl T., *Texas City, Texas*
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Meredith, Robert E., *Corvallis, Oregon*
Mills, Samuel H., *Youngstown, N. Y.*
Moes, Heinz, *New Brunswick, N. J.*
Mook, Harvey W., Jr., *Nashville, Tenn.*

Nestor, John W., Jr., *Wilmington, Del.*
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Nickerson, J. K., *Baytown, Texas*

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Riddick, C. F., *Orange, Texas*
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Sassenrath, C. P., *Camas, Wash.*
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Sears, Max E., *Port Neches, Texas*
Shell, Lee, Jr., *St. Louis, Mo.*
Somekh, George S., *New Rochelle, N. Y.*
Speaker, Stanley M., Jr., *Kalamazoo, Mich.*
Spector, Eric, *Cincinnati, Ohio*
Stebbins, James A., *Vancouver, Wash.*
Stiles, Carrol J., *Akron, Ohio*
Suiter, Raymond C., *Billings, Montana*
Symonds, Chas. E., *Willowdale, Ont., Can.*

Tickner, Roy A., *Atlanta, Georgia*

Van Zyl, Raymond B., *St. Paul, Minn.*

Walton, Stephen A., Jr., *Erlton, N. J.*
Wasser, John H., Jr., *Louisville, Ky.*
Werner, Kenneth R., *Pittsburgh, Pa.*
Wilkins, Jerry D., *Kirkwood, Mo.*
Williams, James M., *South Charleston, W. Va.*
Wright, Bruce R., *Glen Rock, N. J.*
Wylie, Paul R., Jr., *Ogden, Utah*

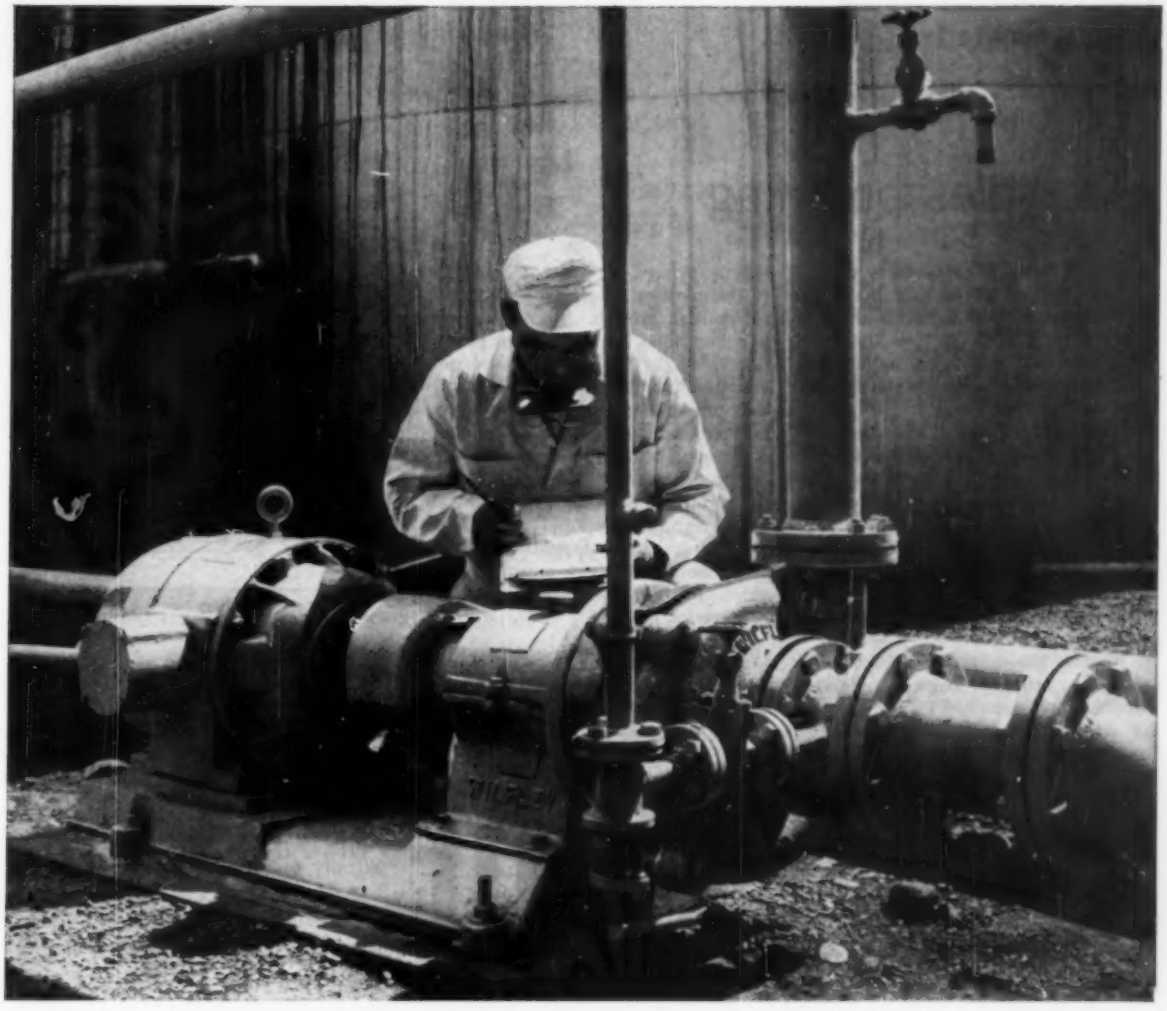
Zeleznik, Frank J., *Wickliffe, Ohio*

A third addition to its electrolytic caustic chlorine plant is planned by Olin Mathieson at McIntosh, Alabama. The expansion, which adds a new cell bank to the two already installed, will serve mid-south customers, particularly those in the rayon and pulp and paper industries.

Another step in Arthur D. Little Company's international expansion program was taken with the opening of an office in Zurich, Switzerland. The research company also recently opened offices in Puerto Rico, and a Research Institute in Edinburgh, Scotland.

Plans underway to double polypropylene production capacity to 25 million annually at the Neal, West Virginia, plant of Novamont, Montecatini American venture. Original plant capacity was set at 11 million pounds, but growing interest in polypropylenes dictated the change. Start-up is still scheduled for early 1961.

Work is now underway on an ethyl chloride-ethylene dichloride unit at Forunna, Canada, for Ethyl Corp. of Canada. The contract awarded to Badger covers Phase 1 construction (foundation and underground work).



Operator checks Ni-Resist pump at Pennsalt Chemical's Portland plant. This particular unit was manufactured by A. R. Wilfley & Sons, Inc. of Denver, Colorado, and pumps caustic at a concentration of 50%. The Duriron Company, Inc. of Dayton, Ohio, also supplied Ni-Resist pumps for the plant.

Ni-Resist pump...eleven years caustic service behind it...years of service ahead

Ni-Resist* pumps have been in caustic service at the Portland, Oregon plant of the Pennsalt of Washington Division, Pennsalt Chemicals Corporation, for eleven years . . .

Eleven years of pumping cell liquor containing 9.3% caustic soda at 170°F to evaporator feed storage . . .

Eleven years of pumping 50% caustic at 80-90°F to storage after concentration . . .

Eleven years of pumping 50% caustic from storage into tanks for shipment.

In regular caustic service, Type 2 Ni-Resist iron offers you proven corrosion resistance. When corrosion resistance *plus* thermal shock resistance are needed . . . Type 3 Ni-Resist iron does the job.

Equipment parts made of Ni-Resist cast iron stand up to alkalies, acids, salts. They resist erosion, protect product purity. What's more, you have eight Ni-Resist irons to choose from. Each one is a proven engineering material with one or more outstanding properties – pressure tightness . . . extra-low thermal expansion . . . high stain resistance.

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industrial news

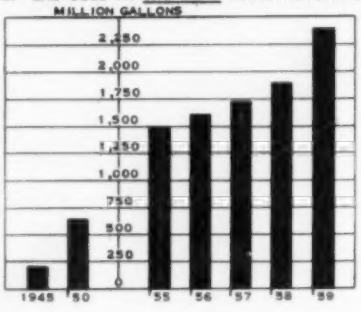
LPG sales booming

Sale of light hydrocarbons during 1959 as a raw material for manufacture of chemicals and chemical intermediates gained 26.7% over the 1958 figure, for a total of 2.396 million gallons, according to a study released by Phillips Petroleum.

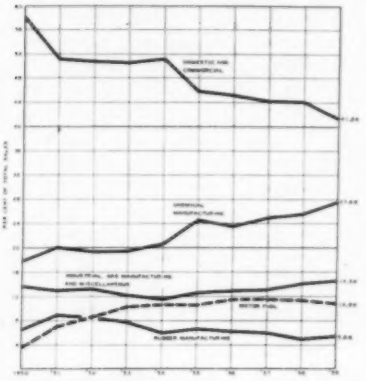
Demand for polyethylene increased more rapidly in 1959 than did production capacity, according to the Phillips report. Sale of polyethylene during 1959 is confidently expected to exceed one billion pounds, while plants now under construction will probably keep production capacity well in advance of demand for some time.

Rapidly-growing markets for polyethylene, ethylene oxide, and ethyl alcohol have resulted in construction of several new ethylene plants and expansions in existing plants. Propane and butane continue to be in demand as feed stock for pyrolytic production of ethylene, although refinery gas streams supply the major volume of ethylene base stocks at the present time.

Propylene from refinery gas and from cracking of propane and normal butane is rapidly growing in demand. Polypropylene, a relative newcomer to the plastics field, gives promise of substantial growth. Since propylene in refinery gas is also used for production of motor fuel alkylate and polymer gasoline, it appears, says Phillips, that propane and possibly butane will be increasingly used in the production of propylene. Butanes are now in heavy demand for motor fuel blending, production of motor fuel alkylate, isomerization of normal butane, and the manufacture of synthetic rubber components. A tight supply picture exists in butanes, especially during the winter season.



Butylenes in refinery gas streams are in increased demand for the production of motor fuel alkylates and synthetic rubbers. Butylene polymers, as



Principal uses of LP gas in percent of total industrial sales.

well as copolymers of ethylene, propylene, and butylenes, are receiving considerable attention for production of plastics, "natural" rubber, and synthetic fibers. Butadiene, in addition to its demand in the production of synthetic rubber, is finding increasing use as a petrochemical intermediate.

Supply picture good

Production of LPG (including the mixed streams going to petrochemical use and refinery fuel) was up nearly 18% over 1958.

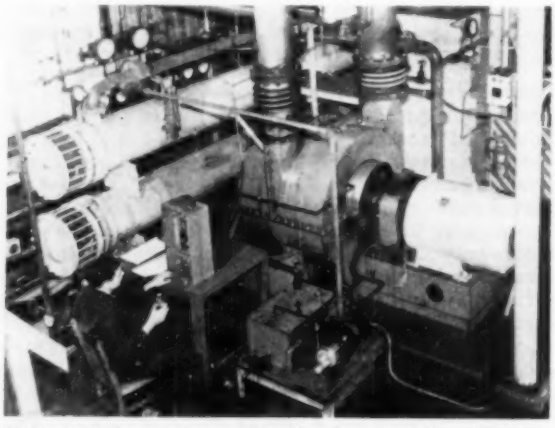
Sulfur from smelter off-gas

Large tonnage production of elemental sulfur envisaged in joint Canadian project of Texas Gulf Sulphur and International Nickel

Eight months of successful pilot plant operation at International Nickel's Sudbury, Ontario, iron ore recovery operation are said to have demonstrated the feasibility of large tonnage commercial production of elemental sulfur by catalytic reduction of smelter off-gases. The sulfur is extracted by reacting high quality sulfurous gas with a chemical reducing agent at high temperature over a specially developed catalyst.

Transportation is key

Sulfuric acid and liquid sulfur dioxide are now being produced in quantity from Inco smelter gases, but because of storage and shipping limitations for these products, it has not been possible to market profitably all the sulfur available in the gases. The proposed production of elemental sulfur, with its reduced shipping cost, is expected to take advantage of low-cost transportation to Eastern Canada and other large consuming areas, say Inco and Texas Gulf.



Pilot plant for recovery of sulfur from smelter off-gases, Sudbury, Ontario.

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13-S. Nuclear Engineering, Part III: The third volume from the Ann Arbor meeting covers pulsed-column techniques; the breeder reactor; recovery of uranium from pitchblende; radiochemical processes; a series of articles on the impact of the atomic field on health, safety of individuals, education, etc.; materials testing reactor, radioisotope utilization. Vol. 50, 274 pp., paper bound; $3.00 to members, $4.00 to nonmembers.

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OTHER PUBLICATIONS

Tray Efficiencies in Distillation Columns—Final Report from University of Delaware and North Carolina State College. Research carried out under grants awarded by the Research Committee of the A.I.Ch.E. with funds from forty-one chemical and petroleum companies:

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Pump Manual—a comprehensive presentation of available data on chemical pumps, including classification of pumps, relationships among categories and types, nomenclature, installation check lists, inquiry and record forms, guides to materials of construction, ASA mechanical standards, and the A.I.Ch.E. Performance Testing Procedure. 8½ by 11 in., loose-leaf format, $10.00 to A.I.Ch.E. members, $20.00 to nonmembers. Published February, 1960.

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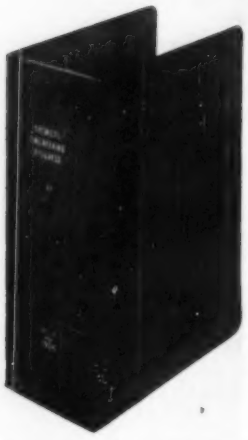

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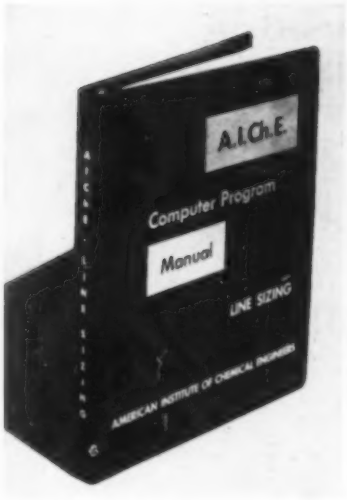

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Other manuals, available during the first half of 1960, will cover heat exchanger design, multicomponent distillation calculations, and estimation of nonlinear equations to represent data.

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meeting preview

Atlanta agenda

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Beautiful gardens greet engineers at Atlanta Biltmore.

The traditional hospitality for which the South is famous will be extended to A.I.Ch.E. members and guests attending the National Meeting at Atlanta February 21-24th. The warmth, it is expected, will also extend to the climate, since an unseasonable day in the 70's is not entirely impossible. Average temperature, however, usually runs around 45° in the month of February. Those who live in climates where the snow flies about that time will be happy to know that golf is an all year round game in Atlanta, and the golf courses on which the all time great Bobby Jones got his start are open to the public.

High spot on the special sevents list of the meeting itself is a repeat of the Special Lecture on Process Development by Statistical Methods. First given at the San Francisco meeting, it was so successful that many members who wished to attend had to be turned away. G.E.P. Box and J. S. Hunter will again deliver the lecture on Saturday, the 20th.

A timely topic, the Soviet Challenge, will be discussed at two sessions. The Sunday afternoon general forum will hear Frank R. Barnett, director of research, The Richardson Foundation, on the Soviet Economic Challenge. On Monday evening the assembly will meet to hear Dean S. N. McMurring, University of Utah, on U. S. A. and U. S. S. R.: Cultures in Conflict.

Featured speaker at the Banquet is E. D. Harrison, president of Georgia Institute of Technology, who will talk on: This Changing World.

Special is another unit operations luncheon, at which specialists on various aspects of the field will lead informal discussions on their specialty.

Plant tours, twelve in all, have been arranged which give a picture of the variegated industries in the Southern metropolis. Georgia Institute of Technology chemical engineering experiment station is of course on the list. A trip to Lockheed Aircraft, Georgia Nuclear Laboratories, is also on the itinerary. The Rome, Georgia plant of Celanese Corporation of America viscose rayon production unit, GE's Rome plant medium transformer department and Swift Agricultural Chemical Division are all open to viewing.

The program arranged for the Ladies is calculated to keep them busy every minute. A tour of Atlanta is tops on the agenda, taking in some of the lovely southern homes made famous in the novel *Gone with the Wind*.

Three-Day Schedule of Technical Sessions

MONDAY, FEBRUARY 22
9:00 A. M.—12:00 NOON

TECHNICAL SESSION NO. 1—MISSILES—ROCKETS.

Chairman: R. B. Filbert, Battelle.

Materials Compatibility with 90% Hydrogen Peroxide, R. C. Kopituk, Thiokol Chemical. Criteria for consideration of different types of metals, ceramic, and plastic materials. State of the art of passivation and new alternate methods.

Chemical Methods and Apparatus to Supply Breathing Oxygen for Long Space Trips, J. P. Foster, Battelle. Two apparently feasible methods compared as to reliability, weight, power requirements, and simplicity of operation at zero gravity.

Burning Rates of Solid Propellants, J. M. Smith, Northwestern Univ. Proposed model based on interfacial reaction between a gaseous molecule and a solid. Combining expressions for rates of heat transfer, diffusion, and reaction leads to relatively simple equations for the burning rate in terms of physical properties, transport coefficients, operating conditions, and chemical characteristics.

Heat Transfer from Thin Gold Films to Water in Swirling Flow, J. D. Fleming & H. V. Grubb, Georgia Inst. of Tech. Burn out heat fluxes ranged from 1.4 to 3.6 million BTU/ (hr) (sq. ft.). Ranges of variables were: tangential velocities of 20 to 80 ft./sec.; axial velocities of 2 to 7.5 ft./sec.; AC currents to 225 amp. and voltages to 80.4.

Propellant Manufacturing Methods for Large Solid Rockets, J. W. Keating & R. D. Geckler, Aerojet General. Improvements in mixing methods, and development of a continuous mixing technique.

TECHNICAL SESSION NO. 2—PESTICIDES—PART 1.

Chairman: D. J. Porter, Diamond Alkali.

The Pesticide Business, J. V. Vernon, Food Machinery & Chemical. Research efforts, now approximating $30 million per year, insure meeting demand for more intensive cultivation of less acreage for a growing population.

The Development of a Pesticide, R. H. Wellman, Union Carbide and Chemicals. Individual facets of a definitive pattern in the evolution of a pesticide.

History of DDT, J. G. Plowden, Geigy Agricultural Chemicals. Discovery, usage, early

continued on page 118

Atlanta Technical Sessions

from page 116

and improved methods of manufacture, aspects of marketing.

Technology of New Pesticides, H. R. Moody, Rohm and Haas. Facilities, people, types of problems encountered in a typical process development. Emphasis on semi-works and plant phases.

TECHNICAL SESSION NO. 3—FILTRATION—PART 1.
Chairman: F. M. Tiller, Univ. of Houston.

Performance of Axial Flow Magnetite Bed Filters on High Temperature Reactor Water, C. F. Paulson, Westinghouse Electric. Pressure drop, backwashing characteristics, effectiveness, in pilot and plant-scale studies at 500°C and 2,000 lb./sq. in.

The Role of Pumping Equipment in Liquid Filtration, C. Jahreis, T. Shriver & Co. A practical stepwise treatment of the interrelationship between filtration characteristics, filter media, and the pump.

The Importance of Residual Mass and Resistance Profiles in Air Filtration, D. G. Stephan & G. W. Walsh, U.S. Public Health Service. The magnitude, generation, and evolution of residual profile variations, and the practical implications of such knowledge.

The Role of Porosity in Filtration—IV, Porosity Variation in Compressible Cakes, F. M. Tiller, Univ. of Houston, & H. R. Cooper, Fluor Corp. Equations which can be used with data from porosity-permeability cells to handle widely varying types of porosity distribution curves obtained with different materials.

2:00-3:00 P.M.
TECHNICAL SESSION NO. 4—FILTRATION—PART 2.
Chairman: F. M. Tiller, Univ. of Houston.

Operation of Trap Type Filters on Water Filtration, J. P. Cannon, James P. Cannon Co., & J. F. Zievers, Industrial Filter and Pump Mfg. Cartridge and surface type filters compared as to floor space, first cost, operating cost. Filter selection considerations.

Filtration Characteristics of Felt Structures, A. C. Wrotnowski, American Felt. Improved performance and characteristics of modern stacked-pad cartridges.

2:00-5:00 P.M.
TECHNICAL SESSION NO. 5—BIOENGINEERING.
Chairman: M. R. Sfat, Rahr Malting Co.

Processing with Electron Irradiation, J. W. Ranftl, General Electric. Technical, engineering, and cost factors involved in planning an installation.

An Isodose Cesium 137 Irradiator, L. Scheib & P. Thurlow, American Machine and Foundry. Detailed description of unit which provides 12,500 roentgens per hour with a variation of less than 2.5% of the mean.

Combined Irradiation — Heat Processing of Canned Foods—IV, Green Peas Inoculated with Anaerobic Bacterial Spores, L. L. Kempe, J. T. Graikoski, & P. F. Bonventre, Univ. of Mich. Sterilization of green peas inoculated with 5,000,000 clostridium botulinum or 300 PA 3679 spores obtained by 1.2 megarad of gamma radiation with an F_o of 0.5.

Purification Process Development Using Radioactive Vitamin B12, H. R. Bungay, M. M. Marsh, & R. C. Peterson, Eli Lilly & Co. Use of commercially available cobalt-60 tagged cyanocobalamin eliminated most of the lag between experimentation and evaluation.

Optimum Design of Fibrous Filters for Air Sterilization, A. E. Humphrey & F. H. Dien-

doerfer, Univ. of Penn. Proposed design method permits optimum design of fibrous filters for removing microorganisms from air streams. Filter media, equipment, and power requirements.

2:30-5:00 P.M.

TECHNICAL SESSION NO. 6—PESTICIDES—PART 2.

Chairman: D. J. Porter, Diamond Alkali.

Industrial Hygiene, W. R. Bradley, American Cyanamid. Design of engineered controls for employee safety in the lab, pilot, production, and formulation plants, warehouses, during shipment, marketing, and in application.

The Formulation of Pesticides, S. H. McAllister, Shell Chemical. Pesticidal activity, residual action, phytotoxicity, mammalian toxicity can be altered by formulation.

Distribution, J. J. Polite, Jr., Diamond Alkali. Unique features involved in distribution of pesticides for the commercial agricultural trade and the small package household items.

2:00-5:00 P.M.

TECHNICAL SESSION NO. 7—KINETICS.

Chairman: C. D. Holland, Texas A & M.

Solution Chemical Kinetics Models on the Analog Computer, J. M. Andrews, Humble Oil & Refining. New techniques for an assumed model demonstrated on a computer to obtain optimum least mean square agreement with data.

Reaction Kinetics in a Baffled Tubular Reactor at Low Flow Rates, R. B. Hovorka & H. B. Kendall, Case Inst. of Tech. For flow rates below Re of 1,500, quartercut baffles in the experimental reactor gave increased conversion. Decreased baffle spacing increased conversion towards that predicted for plug flow.

Diffusion Rates in Porous Catalysts, J. P. Henry & J. M. Smith, Northwestern Univ. Diffusion rates measured in porous alumina particles having a pore volume of 1.35 cc/gm, and a surface area of 280 m/gm.

Selectivity in Experimental Reactors, J. J. Tichacek, Shell Development. Kinetics, yield, product distribution data from a reactor are assumed to depend on operating conditions and not on scale. The validity of the assumption in the presence of axial mixing is discussed.

A Thoroughly Stirred, Mechanically Fluidized Catalytic Reactor, I. P. Trotter, Jr., & R. H. Wilhelm. Princeton Univ. Thermal and concentration gradients are minimized, with good thermal uniformity shown for a highly exothermic reaction.

8:00-9:30 P.M.

GENERAL SESSION—USA AND USSR: CULTURES IN CONFLICT.

Speaker: S. N. McMurrin, Univ. of Utah.

TUESDAY, FEBRUARY 23

9:00 A.M.-12 Noon

TECHNICAL SESSION NO. 8—TEXTILES.

Chairman: J. E. Warner, Goodyear Tire and Rubber.

The Textile Industry, P. M. Thomas, McGraw-Hill Publishing.

Textiles, L. Crouch, Beaunit Mills.

Textile Finishing, D. D. Gagliardi, Gagliardi Research Corp.

Tire Cord, B. D. Mallory, Goodyear Tire & Rubber.

Coated and Impregnated Fabrics: Carpet, J. J. Hanlon, Mohasco Industries.

Coated and Impregnated Fabrics: Non-Woven Fabrics, D. Charleston, West Point Mfg.

Textile Growth Potential, L. H. Hance, Inst. of Textile Tech.

TECHNICAL SESSION NO. 9—WASTE TREATMENT.

Chairman: W. W. Eckenfelder, Jr., Manhattan College.

The Effect of Surface-Active Agents on Gas Absorption, D. J. O'Connor, Manhattan College. A theoretical development based on the Gibbs equation used to calculate the relationship between the influence of surface-active agents and gas absorption, and compared to laboratory data for oxygen and carbon dioxide.

The Effect of Organic Substances on the Transfer of Oxygen from Air Bubbles in Water, W. W. Eckenfelder, Jr., & E. L. Barnhart, Manhattan College. Effect of organic additives on the properties of the liquid, the size of the air bubbles, and diffusion characteristics of oxygen into the solution related to changes in the liquid film and the overall film coefficient.

Mass Transfer in Biological Treatment, R. F. Weston, V. T. Stack, Jr., & W. D. Sitman, Roy F. Weston, Inc. Relationships controlling BOD removal, sludge production, sludge destruction, and oxygen consumption for activated sludge systems. Additional relationships for trickling filters.

TECHNICAL SESSION NO. 10—HIGH PRESSURE TECHNOLOGY.

Chairman: H. R. Batchelder, Battelle.

Low Frequency Induction Heating Applied to High Pressure Batch Reactions, K. L. Burgess & J. T. Donovan, Dow Chemical. A compact economical system utilizing 60 cycle induction heating has proven to be a versatile laboratory device.

The Bulk Modulus Cell: A New Instrument for Measuring High Pressure, D. H. Newhall & L. H. Abbot, Harwood Engineering. Design, construction, and applications.

The Development of Ultra Safe High Pressure Austenitic S. S. Bourdon Pressure Gauges, J. C. Bowen & R. C. Wolf, Astra Corp. A case design for safety under hazardous conditions in pressure ranges from 10,000 to 100,000 lb./sq. in.

Ultrahigh Pressure—A New Tool for Chemical Synthesis, C. M. Schwartz, Battelle. Apparatus and techniques to attain and apply pressures such as 5,000,000 lb./sq. in.

2:00-4:30 P.M.

TECHNICAL SESSION NO. 11 — NUCLEAR FEED MATERIALS PROCESSING.

Chairman: D. S. Arnold, American Potash and Chemical.

Sampling Aspects of Uranium Materials, W. L. Lennemann, A.E.C. A survey of present methods with emphasis on concentrates and refined products.

The Use of a Fluidized Bed for the Continuous Production of U_3O_8, E. P. Sanders, W. T. Trask, & W. C. Philoon, Mallinckrodt Chemical. Study of bed temperatures of 500 to 800°F, and production rates up to 300 lb. of uranium trioxide/hr/sq. ft. of reactor cross section with feed concentrations as high as 12 lb of uranium/gal.

De-Entrainment in Evaporators, C. S. Schlea & J. P. Walsh, Du Pont. Design data for de-entrainers in which the water jets impinge on flat surfaces.

Effects of Radiation Levels on Maintenance of Army Package Power Reactor, C. A. Bergmann, Alco Products. Methods of reducing activity build-up and the effects of radioactivity on maintaining components such as the generator, pump and purification system.

2:00-5:00 P.M.

TECHNICAL SESSION NO. 12—SELECTED PAPERS SESSION—EDUCATION.

Chairman: H. V. Grubb, Georgia Tech.

Closed-Circuit Television in Engineering Education, J. R. Martin, Case Inst. of Tech. Advantages as an instructional aid, particularly in laboratory and research work, and for demonstrating to large groups.

Russian Chemical Engineering Literature, L. W. Ross, Georgia Tech. Content, how it may be obtained, how to extract information from Russian sources even without translation.

continued on page 120

from page 119

Forced Convection Heat Transfer with Flow Normal to Fine Wires, J. B. Roach & T. F. Goodgame, Georgia Tech. Heat transfer from 0.010 in. diameter wire at temperatures from 40 to 200°C to water at 20°C to 90°C flowing normal to the wire at from 1 to 4 ft./sec.

Heat Transfer to Fluids in Turbulent Motion by Analogy to Momentum Transfer, R. J. Hefner & D. L. Franklet, Georgia Tech. Two mathematical models postulated for the analytical prediction of heat transfer coefficients give reasonably good agreement with experimental data for fluids with Prandtl numbers ranging from 0.01 to 100.

2:00-5:00 P.M.

TECHNICAL SESSION NO. 13—SELECTED PAPERS SESSION—ORGANICS.

Chairman: C. A. Burdell, Southern Wood Preserving Co.

Effect of Gamma Irradiation on the Catalytic Activity of Zinc Oxide and Chromic Oxide for the Decomposition of Methanol, A. J. Teller, F. L. Poska, & H. A. Davies, Univ. of Florida. Under steady-state conditions, the catalytic activity of a P-type semi-conductor catalyst (Cr_2O_3) was decreased under irradiation, whereas the activity of an n-type catalyst (ZnO) increased under irradiation.

Electrical Precipitation of Treated Petroleum Streams, R. J. Phillips, W. M. Fisher, & J. R. Humble, Jr., Howe-Baker Engineers. Electrical precipitation applications in the petroleum refinery industry with emphasis on the economic advantages over gravity settling methods.

The Status of Liquid Mixed Fertilizer Technology, A. V. Slack, TVA. Advantages, problems, and developments in use of solutions of fertilizer salts.

Mass Transfer in Semi-Fluidized Beds for Solid-Liquid System, L. T. Fan & Y. C. Yang, Kansas State Univ., C. Y. Wen, West Virginia Univ. Data in terms of mass transfer factors and overall void fractions for both packed and fluidized sections for a benzoic and water system.

WEDNESDAY, FEBRUARY 24

9:00 A.M.—12 Noon

TECHNICAL SESSION NO. 14—MINERAL ENGINEERING.

Chairman: W. A. Koehler, West Virginia Univ.

Chemical and Mechanical Behavior of Cermets, T. S. Shevlin, Ohio State Univ. Chemical behavior in terms of resistance to sintering and reactions in oxidizing and reducing environments, and mechanical behavior in terms of bond types within, and mechanical interaction between, crystals of the constituent phases of fabricated cermets.

Use of Thermite Reactions to Produce Refractory Cermets, J. D. Walton, N. E. Poulos, & C. R. Mason, Georgia Tech. Methods for forming silicides, borides, and carbides, and their application to several high temperature areas. Tensile and transverse strength data for zirconium-disilicide bonded aluminum oxide.

A Method for Producing Pilot Quantities of Diborane, W. A. Samuel, Callery Chemical. Description of a batch-process facility with a capacity of about 100 lb./day.

Application of Engineering and Mineral Economics to Industrial Growth, F. Bellinger & J. E. Husted, Georgia Tech. The status and growth picture of minerals.

TECHNICAL SESSION NO. 15—SELECTED PAPERS SESSION—MANAGEMENT AND AIR POLLUTION.

Chairman: C. A. Burdell, Southern Wood Preserving Co.

Chemical Engineering Sales Policies of Small Firms, D. H. Jackson, Croll-Reynolds. Sales policies in relation to selling chemicals and raw materials, standardized and custom-built products, commission sales versus salaried agents, competition.

Small Company Sales to the Chemical Industry, L. A. Schnurr, W. P. H. Schultz, Inc. The small company can achieve an edge over larger competitors through a well coordinated organization effecting a wider understanding of various problems.

Utilization of Low Weight Plastic Packed Columns for Air Pollution Control, P. W. Arndt, Heil Process Equipment. Case histories of several installations during recent years presented on the basis of costs, efficiencies, and unique installations possible because of the reduced overall weight.

Efficiencies, Capacities, and Power Requirements of Pollution Control Equipment, A. J. Teller, Univ. of Florida. Packed towers, spray towers, and jet, venturi, cyclone, and impact scrubbers compared.

TECHNICAL SESSION NO. 16—SELECTED PAPERS SESSION—FLUIDS.

Chairman: J. F. Kinney, Georgia Tech.

Non-Newtonian Velocity Distribution Measurements by the Tracer Displacement, F. M. Richardson, P. H. McGinnis, & K. O. Beatty, North Carolina State College. Comparison between experimental profiles and those calculated from the usual empirical power law relationships.

Determination of Diffusion Coefficients in Binary Solutions of Non-Electrolytes, M. P. Gautreaux, Jr., Ethyl Corp., W. T. Davis & J. Coates, Louisiana State Univ. Diffusion coefficients for concentrated thermodynamically non-ideal systems in ethanol-water at 25°C in a simple potential cell.

Combined Free and Forced Convection in a Constant Temperature Horizontal Tube, T. W. Jackson, J. M. Spurlock, & K. R. Purdy, Georgia Tech. Equations for air in a horizontal tube to fit the laminar flow range of Graetz numbers from 60 to 1,300 and for the data with the air in turbulent flow.

Dialysis of Concentrated Electrolyte Solutions, B. H. Vromen & N. S. Chamberlin, Graver Water Conditioning. Data from stirred batch dialysis experiments compared with countercurrent continuous experiments.

industrial news

Construction of a $1,600,000 low temperature gas separation unit in Yugoslavia given the go-ahead signal by the Yugoslavian government. Design capacity of the plant calls for 100,000 tons of oxygen and 120,000 tons of ammonia synthesis gas yearly. Contract for construction went to L'Air Liquide, while the project is financed by the Development Loan Fund in Washington.

Just formed in Switzerland is a wholly owned subsidiary of National Distillers and Chemical. Purpose: to expand sales in world markets of polyethylene manfactured by the company's US Industrial Chemicals Division. Temporary headquarters for the new company, U.S.I. International, are in Barr, Switzerland.

Aluminum alkyls and alkyl aluminum halides are in increased production at Ethyl. The company just completed a plant at Orangeburg, S.C. which along with other production methods uses a triethyl aluminum process developed by Ethyl. Some promising applications of the compounds are as intermediates in producing other chemicals, and as pyrophoric fuels for military applications.

A 70 percent expansion in sulfuric acid capacity slated at Pittsburgh Coke and Chemical's Neville Island plant, will supply company requirements in processing chemicals from the gas system of its own coke ovens. The sulfuric will also be marketed in the Pittsburgh area, when the new facility is finished in 1961.

Italy's third nuclear research reactor facility will be built for CAMEN, Italian government agency, by Vitro International. The pool type reactor, capacity 5000 kilowatts, will be used to train Italian naval cadets and engineering students at the University of Pisa. Architect-engineers, Vitro's Italian subsidiary Vitro Italiano, have scheduled on-stream date early in 1961.

Hercules Powder plans construction of manufacturing facilities for methanol, formaldehyde, urea formaldehyde concentrates and slow nitrogen release urea-form for fertilizer applications at its Hercules, California, plant. Yearly capacity will be 8 million gallons of methanol, 50 million pounds of formaldehyde, and 11 thousand tons of ureas formaldehyde compositions.

One of the world's few non-integrated bamboo pulp units, a mill, is planned for 100 ton a day capacity, at Lamsakhang, Assam, India. The completely self contained project undertaken by Assam Pulp Mills, Ltd. will provide all its own services and principal chemicals, will ship pulp in dry sheet form for conversion to paper by conventional methods.

A research center to be constructed by Kordite (National Distillers), at Macedon, New York, will contain facilities for research in plastics and packaging, as well as technical service areas. The $2 million building should be ready for full occupancy by January, 1961.

A $2 million chemical manufacturing facility under construction for Tretolite (Petrolite) at Brea, California, is due for completion in mid-1960. The company will move from offices in Los Angeles to the new site.

future meetings

1960—MEETINGS—A.I.Ch.E.

● Atlanta, Ga., Feb. 21-24, 1960. Hotel Atlanta Biltmore. **A.I.Ch.E. National Meeting.** See page 116.

● Chicago, Ill. Feb. 23, 1960. Palmer House. **Chicago Section A.I.Ch.E. One-Day Symposium** on Engineering Economics and Computer Control of Process Units. Tech. Prog. Chmn.: R. S. McDaniel, Std. Oil Ind.

● Mexico City, Mex. June 19-22, 1960. Hotel Del Prado. **Joint Meeting with Instituto Mexicano de Ingnieros Quimices** — Tech. Prog. Chmn.: G. E. Montes, Northern Nat. Gas Co., 2223 Dodge St., Omaha 1, Nebr. **Petroleum & Natural Gas Processing in Latin America**—F. W. Jessen, Petrol. Eng. Dept., U. of Texas, Austin, Tex. & P. Corcuera, Ref. Madero, Tamps, Mex. **Chem. Engineering in Latin America**—G. Mayurnik, W. R. Grace, 3 Hanover Sq., New York 4, N. Y. & S. Vasan, Chem. Constr. Corp., 525 W. 43 St., New York 36, N. Y. **Chemical Engineering Education in the Americas**—W. R. Marshall, Jr., Dean, U. of Wisconsin, Madison 6, Wisc. & P. G. Roel, Inst. Tec. y de Estudios Sup. Sucursal de Corres J., Monterey, Nuevo Leon. **Machine Computation-Optimization, Pitfalls, and Potentials**—W. M. Carlson, Louviers Bldg., Dupont, Wilmington 98, Del. **Distillation Equipment**—R. Katsen, 3732 Dogwood, Lane, Cincinnati, O. & P. Ocampo, PEMEX, Vallarta #7-4° Piso, Mex., D. F. **Minerals and Metals**—D. B. Coghlan, Foote Mineral Co., Box 576, Berwyn, Pa. **Transfer Processes in Two-Phase Systems**—S. G. Bankoff, Ch.E. Dept., Northwestern U., Evanston, Ill. & A. Hoyos, Xola #1253-2° Piso, Mex., D. F. **Construction and Operating Costs for Latin American Projects**—R. Voorhees, Union Carbide Dev. Co., 30 E. 42 St., N. Y. 17, N. Y. & R. Pardo, Dir. Bufete Ind., Insurgentes sur 132-102, Mex., D. F. **Laboratory and Pilot Plant Techniques**—J. T. Cumming, Fenn College, Cleveland 15, O. & M. Puebla, Inst. Mex. de Invest. Tec., Calzada Legaria #694, Mex., D. H. **Cryogenic Engineering**—F. Kurata, Ch.E. Dept., U. of Kansas, Lawrence, Kan. **Selected Papers**—J. A. Samaniego, Shell Dev. Co., Emeryville 3, Calif. & S. S. Menache, Calderone de la Barca, #417, Mex., D. F. **Financing International Projects**—P. F. Genachte, Chase-Manhattan Bank, New York, N. Y. & J. Horcasitas, Credito Bursatil, Isabel la Catolica #38, Mex., D. F. **Student Program**—J. J. McKetta, Ch.E. Dept., U. of Texas, Austin, Tex.

Deadline for papers: January 19, 1960.

● Moscow, USSR, June, 1960, 1st Congress of International Fed., Automatic Control. To cover areas of **Theory, Hardware & Applications of Automatic Control,** U. S. participation sponsored by American Automatic Control Council. Affiliated societies: **A.I.Ch.E., ASME, AIEE, IRE, ISA.** A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prods., Des Plaines, Ill. For attendance & deadline info write: Secy., W. E. Vannah "Control Engrg.", 330 W 42 St., N. Y. 36, N. Y.

● Buffalo, N. Y., Aug. 14-17, 1960. Statler Hilton Hotel **4th National Heat Transfer Conference & Exhibit. Sponsored by A.I.Ch.E. & ASME.** A.I.Ch.E. papers to S. W. Churchill, U. of Mich., Ann Arbor, Mich. ASME papers to J. P. Hartnett, U. of Minnesota, Minneapolis, Minn. Exhibit info to P. A. Joculvar, A.I.Ch.E., 25 West 45 St., N. Y. 36, N. Y.

● Tulsa, Okla., Sept. 25-28, 1950. Hotel Mayo. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: K. H. Hachmuth, Phillips Petroleum Co., Bartlesville, Okla. **Multiphase Flow in the Production & Drilling of Oil Wells**—L. P. Whorton, Atlantic Refining, Box 2819, Dallas 1, Texas. **Natural Gas & Natural Gas Liquids**—R. L. Huntington, U. of Oklahoma, Norman, Okla. **Advances in Refinery Technology**—W. C. Offutt, Gulf R&D Co., P. O. Drawer 2038, Pittsburgh 30, Pa. **Petrochemicals**—C. V. Foster, Continental Oil Co., Ponca City, Okla. & H. L. Hays, Phillips Chem. Co., Bartlesville, Okla. **Piloting, or Why Buy the Restaurant When All You Need is a Meal**—R. E. Weis, Phillips Pet. Co., Bartlesville, Okla. & D. Popovac, Continental Oil Co., Ponca City, Okla. **Corrosion & Materials of Construction**—W. A. Luce, The Duriron Co., P.O. Box 1019, Dayton 1, O., & M. S. Whorley, Black, Sivalls & Bryson, P.O. Box 1714, Oklahoma City, Okla. **Statistics and Numerical Methods Applied to Engineering**—R. L. Heiny, 2709 Jefferson, Midland, Mich. **Air & Ammonia Plant Safety**—G. Weigers, Amer. Cyanamid Co., Rockefeller Plaza, New York, N. Y. **Refinery & Natural Gasoline Plant Safety**—J. N. Romine, Phillips Petrol., Bartlesville, Okla. **Processing Agricultural Products**—A. Rose, Tex. Eng. Exp. Sta., Tex. A&M Coll. Sta., Tex. **Chemical Reactions Induced or Modified by Radiation**—J. J. Martin, Ch.E. Dept., U. of Mich., Ann Arbor, Mich. **Conservation & Utilization of Water**—P. J. Lockhart, Ch.E. Dept., U. of So. Cal., 3551 University Ave., Los Angeles 7, Cal. **Foams**—C. S. Grove, Jr., Syracuse U., Syracuse 10, N. Y. & R. L. Tuve, U.S. Naval Rsch. Lab., Wash. 25, D.C. **Computers as a Management Tool**—R. Cziner, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Non-Newtonian Fluid Mechanics**—A. B. Metzner, U. of Delaware, Newark, Del. **Student Program. Selected Papers**—R. H. Perry, Ch.E. Dept., U. of Oklahoma, Norman, Okla.

Deadline for papers: May 2, 1960.

● Washington, D.C. Dec. 4-7, 1960. Statler Hotel. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: D. O. Myatt, Science Communication, Inc., 1079 Wisconsin Ave., N.W., Wash. 7, D.C. **Air Pollution**—A. J. Teller, U. of Florida, Gainesville, Fla. **Unsteady—State Instrumentation**—T. J. Williams, Monsanto Chem. Co., St. Louis, Mo. **Fluid Dynamics**—A. C. Acrivos, U. of California, Berkeley, Calif. **Information & Communications**—D. E. Gray, NSF, Wash. D.C. **Nuclear Reactor Operations**—R. L. Cummings, Atomics International, Canoga Park, Calif. **Nuclear Chemical Plant Safety**—C. E. Dryden, Ohio State U., Columbus, O. **Phase Transitions**—G. Bankoff, Northwestern U., Evanston, Ill. **Selling Abroad**—J. Costigan.

SAVE THOSE BACK ISSUES!

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All these issues were overprinted to the usual extent, but because popular features spurred single copy sales, our reserves are exhausted.

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Deadline for papers: July 5, 1960.

1961—MEETINGS—A.I.Ch.E.

● New Orleans, La., Feb. 26-Mar. 1, 1961. Hotel Roosevelt. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: H. L. Malakoff, Petroleum Chem. P.O. Box 6, New Orleans 6, La. **Kinetics of Catalytic Reaction; Brainstorming Technical Problems; Petrochemicals—Future of the Industry on Gulf Coast; Centrifugation; Future Processing Technologies in the Petroleum Industry; Education and Professionalism; Mathematics in Chemical Engineering; Evaluation of R&D Projects; Liquid—Liquid Extractions; New Processes in the Area; Water from Sea Water; Materials of Construction; Flow Through Porous Media.**

Deadline for papers: Sept. 5, 1960.

● Cleveland, O., May 7-10, 1961. Sheraton-Cleveland. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 10, O. **Management Criteria for Capital Investment; Technical Phases of the Synthesis of Isoprene; Process Development of the New Synthetic Rubbers; Use of Radioactive Materials for Chemical Process Control; Modernized Processes for Heavy Chemical Manufacture; Optimum Utilization of Pilot Plant Facilities; Petrochemicals as The Starting Materials for High Polymers; Chemical Engineering and Metal Refining; Fluid Mechanics; Applications of Photography in Chemical Engineering.**

Deadline for papers: Dec. 7, 1960.

● Lake Placid, N. Y. Sept. 24-27, 1961. Lake Placid Club. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: E. R. Smoley, Lummus, 385 Madison Ave, New York 17, N. Y. **Process Management; Commercial Chemical Development; Sales Engineering.**

● New York, N. Y. Dec. 3-6, 1961. Hotel New Yorker. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: A. V. Caselli, Shell Chem Corp., 50 W. 50 St., N. Y. 20, N. Y. **Heat Transfer; Management; New Processes; Nuclear Engineering; Water Pollution; Process Dynamics; Pilot Plants; Fundamentals; Petroleum & Petrochemicals; Fluids; Fluidization; Sublimation; Adsorption; Student Program.**

1962—MEETINGS—A.I.Ch.E.

● Los Angeles, Calif. Feb. 4-7, 1962. Hotel Statler. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: G. C. Szego, Space Technology Labs, Inc., P.O. Box 95.001, Los Angeles 45, Calif.

● Baltimore, Md. May 20-23, 1962. Lord Baltimore Hotel. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: G. L. Bridger, R&D Div., Washington Research Center, W. R. Grace, Clarkesville, Md.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

Computers in Optimum Design of Process Equipment—Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

Solar Energy Research—J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison, Wis.

Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbus, Mo.

Process Dynamics as They Affect Automatic Control—D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

Drying—R. E. Peck, Ill. Inst. of Tech., 330 So. Federal, Chicago, Ill.

equipment feature

R. A. Troupe, J. C. Morgan, & J. Prifti
Northeastern University, Boston, Mass.

The plate heater – versatile chemical engineering tool

Although widely used by the dairy industry, today's modern version of the plate heater has not received the attention from the chemical industry which its versatility and efficiency warrant.

The chemical engineer will have no difficulty in recognizing the similarity of this heat exchange apparatus to the plate and frame filter press. Indeed, the filter press served as the inspiration for the development of the ancestor of the modern plate heat exchanger nearly 100 years ago. Essentially, the plate type apparatus differs from conventional heat exchangers in three respects:

1. Control of flow arrangements of the heat transfer media.
2. The shape of the flow passages.
3. Characteristics of heat transfer and pressure drop.

The plate heater consists of a number of rectangular thin metal plates with corner openings mounted between a top carrying bar and a bottom guide bar. The group of plates is clamped tightly between a fixed headpiece and a movable follower or tailpiece. Each plate is stamped out of sheet metal in such fashion that its surface has a corrugated or wavy appearance. When a series of plates are clamped together the corrugations on successive plates interlock to form the narrow flow channels. The pattern of this corrugation varies between manufacturers. The purpose of the wavy pattern on the plates is to produce turbulence even at low velocities thereby increasing the effectiveness of heat transfer. The corrugations also increase the rigidity of the thin plate enabling it to better withstand the stresses to which it is subjected.

The heat transfer plates are arranged face to face with the heating and cooling streams flowing on opposite sides of each plate. The distance between plates, or the fluid channel width, is determined by the thickness of the gasket surrounding each plate. When the plates are compressed by tightening the mechanism which forces the plates together in a manner similar to a filter press, the gaskets seal the fluids in the apparatus and prevent leakage. It can be seen that it is important that the apparatus be tightened to the same extent each time. Various safeguards are provided by the manufacturers to insure this uniform compression.

In flowing through the apparatus, a fluid enters at a corner of one end of the compressed pack of plates. It passes through alternate plates in either series or parallel passages, the routing determined by whether or not the corner opening on each plate opens onto the channel or is blocked off. By means of intermediate devices, called connector plates, the fluid can be subjected to several different types of heat exchange (e.g. heating and cooling) or removed from the apparatus for other processing and returned to the apparatus for a second heat transfer cycle. In every case, each channel containing a heat exchange fluid is sandwiched between two channels carrying the other heat exchange fluid except at the ends of the apparatus.

Turbulance at low flows

The effectiveness of the plate heater as a heat transfer apparatus is due in large measure to the fact that the fluids being heated and cooled flow in thin films. The plate spacing is usually 3-5 mm. Frequent changes in direction and velocity created by the zig-zag pattern of the plates produces turbulence at relatively low flow rates. Figure 1 presents a Reynolds number-friction factor chart for an experimental plate heater. It can be seen that this plot is of the same form as the Reynolds number-friction factor plot for pipes but instead of the lower critical value being 2100 as for pipes it is about 200. In other words, turbulent flow in a plate apparatus oc-

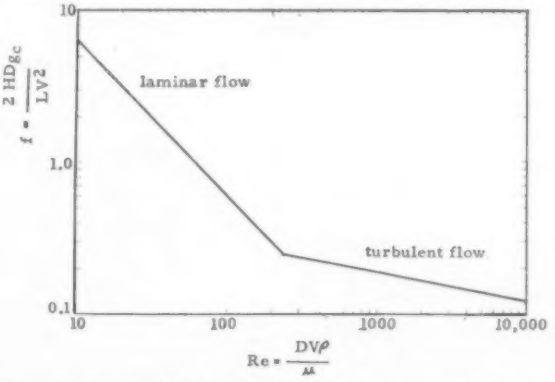

Figure 1. Reynolds number-friction factor chart for an experimental plate heater.

curs at a much smaller velocity than in a pipe of equivalent size. This is especially important in the case of high viscosity fluids.

Because of the turbulence at low velocities it is possible to obtain film coefficients which are equal to values for tubes in which the Reynolds numbers are five times higher. In fact at comparatively low velocities film resistances become so small that the controlling resistance to heat transfer is the metal wall—as is the case with stainless steel plates.

Plates are manufactured of stainless steel, cupro-nickels, Hastelloy C, titanium, and similar metals and alloys. Most commonly the plates are fabricated of the stainless steels, usually type 304 or 316, because of physical properties, resistance to corrosion, and ability to take a high polish. But stainless steel has a low thermal conductivity compared to copper and copper base alloys. Fortunately its physical properties allow it to be fabricated into plates which are relatively thin yet with sufficient rigidity for this use. Depending on material of construction and manufacturer, plate thicknesses vary from 0.05 to 0.125 inch. Development of plate manufacture from some of the newer commercial metals and alloys will undoubtedly improve the conductivity of the wall.

One of the great advantages of plate heaters is that they can utilize up to 82% of the theoretical log mean temperature drop while shell and tube exchangers can utilize only about 50% of it. This is mainly due to parallel flow (fluid flow deviating from the main flow direction) which occurs because of the baffles and resulting cross flows in tubular exchangers. The advantage of this is seen in heat recovery from process streams where it is not unusual to realize high efficiency with temperature differences as low as 5 degrees. This small temperature difference makes possible a satisfactory regulation of heat transfer. Wall temperatures can be kept low, an important consideration when a sensitive or depositing fluid is being handled.

The advantage of the plate heater is less pronounced when steam or a condensing vapor is one of the fluids. Moreover, for best results the steam should be introduced at the bottom and the condensate removed from the top.

Heat losses to the surroundings are low because only the narrow edge of the plate and the gasket edge are exposed.

The analogy between heat transfer and fluid flow indicates that as the heat transfer is improved the pressure drop is also increased. This will raise the question as to whether it is practical to utilize a plate heater for its greater heat transfer when this improvement is obtained at the expense of a larger pressure drop. While it is true that the pressure drop in a plate heater will be greater than the pressure drop in a tube type heat exchanger at the same velocity, this is hardly a fair basis for comparison. If the comparison is made between the two types at the same heat transfer area or at the same overall coefficient of heat transfer, the pressure drop in the plate heater is lower. Modern design has resulted in corner openings on the plates with negligible resistance so that practically the entire pressure drop is available for the passage between the plates.

No discussion of the advantages of the plate heater would be complete without mention of the versatility of this apparatus. Since the entire apparatus can quickly and easily be taken apart into its individual components, the heat transfer area can be changed or rearranged for a different task or cleaned with little difficulty.

Using a single plate size, one can economically cover a range of flow rates of the order of 10 to 1. It is a comparatively simple task to calculate the number of plates and the arrangement of plates for a particular operation. If the needs change at some later time the area can be increased or decreased or rearranged by opening the frame, moving plates as needed, and closing the frame again. All of this requires no mechanical skill.

It is possible to perform many different heat exchange operations within the same framework. By the use of connector plates it is possible to heat, cool, and recover heat as many times as desired within the single piece of equipment. Further, it is possible to direct a fluid through a portion of the exchanger to heat or cool it, to then send it through another apparatus outside the plate heater, such as a filter or homogenizer,

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Plate heaters

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and finally to direct the stream back into the plate heater for a second heat transfer operation.

Operations such as this are quite common in the dairy industry where, for example, raw milk receives heat from a stream of pasteurized milk in a section of the heater. This raw milk is next heated to a higher temperature by steam or hot water in a second section. The steam or hot water need only be 1-2° above pasteurization temperature. The milk then flows through a retention system external to the heater where its temperature is maintained for the proper time for pasteurization. This pasteurized milk reenters the plate heater where it is cooled by the entering raw milk. Here recovery of 85% of the heat is not unusual. Finally the milk passes to a third section of the heater where it is cooled further by water or other coolant. Obviously such devices as filters and homogenizers can be incorporated into the system.

To perform the various tasks required one can send the fluid through the exchanger in series, or split the flow into several parallel streams, or use a mixed flow pattern. By intelligent choice of the flow pattern one can achieve the best combination of capacity, heat transfer, and pressure drop for his particular needs.

All of this requires comparatively little floor space. For example, one commercial plate exchanger having a heat transfer area of 857 square feet requires a floor space 119 inches by 25 inches and stands 70⅝ inches high.

Another obvious asset of this apparatus is the ease with which it can be cleaned. Because the flows are completely isolated from the atmosphere, contamination by bacterial action or oxidation is virtually impossible. If however, the heat transfer surfaces need to be cleaned because of sanitary requirements or because of the deposit of solids it is a simple matter

to circulate cleaning solutions through the exchanger. To remove tenacious, closely adhering deposits the press is opened and the individual plates cleaned in place with a hose and brush. This cleaning may be performed by the operator without mechanical assistance and without dismantling the sytem. Further a visual inspection of all surfaces is possible before putting the exchanger back into service.

Plate heaters are especially well adapted to use with viscous fluids. First, since turbulent flow begins at much lower Reynolds numbers than for tubes it is difficult, even with highly viscous fluids, to experience the poor heat transfer associated with the laminar zone. Secondly, for non-Newtonian fluids, the viscosity in the apparatus is lower than the apparent viscosity, due to the turbulence created by the wavy pattern of the plates.

Despite introduction and discharge of the fluids at corner openings of the plate and despite the width of the flow channel no stagnant areas occur and the temperature drops normally over the length of the plate.

Disadvantages

The Achilles heel of the plate heater is the gasket. For a plate having approximately 1.5 square feet of heat transfer area about 90 linear inches of gasketing are required. The most common gasketing material is rubber which proves satisfactory for many applications. It is a simple job to replace one of these gaskets in the field.

High temperatures (above 300°F) and organic solvents are injurious to the rubber gaskets and so impose a limitation on the field of usefulness of the apparatus. The use of other materials such as cork and lead has been reported for certain applications. The development of conventional gaskets from substances such as Teflon and some of the silicones should lead to the compounding of improved gaskets for plate heaters to be used in severe applications.

The top operating pressure has been raised considerably since the introduction of the apparatus but is still limited to 200 psi or less.

Since the flow passages between plates are thin and unalterable in size it follows that the liquid rate which can be passed through the plate heater without excessive pressure drop limits the capacity. Since the frames are finite in size the total length of heat transfer surface which can be provided—that is, the number of plates—is limited. Some manufacturers however feature interchangeable support bars which can be used to lengthen the exchanger when necessary. The upper limit for expansion at present is about 1600 square feet of heat transfer surface.

While the turbulence in the plate heater allows it to handle fluids with considerable amounts of solids in suspension one must recognize that the distance between plates is small. If solids are large or tend to deposit, the plate heater will clog more readily than a tube.

Finally, it should be repeated that the advantage of the plate heater in heat exchange is much less pronounced when steam or condensing vapors are used.

Costs

The decision as to whether or not it is economical to purchase a plate heater depends largely on the evaluation of three factors—the material of construction, the complexity of the use to which it is to be assigned, and the possible need for later modification of the heat transfer area. From the material standpoint initial costs for plate heaters are higher than those for conventional tubular exchangers unless stainless or similar corrosion-resistant construction is specified. For complex uses where several heat exchange operations are required one plate heater is less expensive than the several tubular exchangers required to be the equivalent of the plate apparatus. The ability to expand the exchanger area with increased need is obvious.

Applications

As noted previously the most extensive use of plate heaters is in the

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Plate heaters

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dairy industry where the apparatus is used for pasteurization, cooling and heating of milk, cream, skim milk, ice cream mix, cheese milk, and evaporated milk. The reason for its ready acceptance by the dairy industry is not difficult to understand. Milk is very heat sensitive and inclined to form a coating on heat transfer surfaces. For pasteurization the required temperature is low and contact time short although both must be closely controlled. In addition the ultimate in cleanliness is required.

The use of plate heaters for pasteurization of milk suggested possible uses in pasteurization of beer, wine, molasses, and fruit juices. Widespread adoption by the beverage and food industries has followed.

The synthetic rubber industry has found this apparatus quite useful for the heating of synthetic latices before removal of excess monomers. One of the major rubber producers also uses a plate heater as an external heating element for evaporators used in the concentration of latex. One heater manufacturer is now advertising an evaporator based on this principle for the concentration of skim milk.

It has been reported that plate type apparatus has been used as coolers or regenerators for cottonseed oil, gelatin solutions, cosmetic solutions, yeasts, alcohol, and glue. The apparatus has also been used to recover heat from process streams in paper mills especially from spent sulfite liquor.

Petroleum processing, the largest user of heat exchange equipment, has not adopted the plate heater to any extent. Probably this is due to the large throughput, high temperatures and pressures, and solvent action of the materials processed—all of which place the plate heater at a disadvantage. Very likely the development of improved gaskets will overcome the latter two problems but very little can be done to raise the throughput to any extent.

industrial news

Production facilities for a wide range of pesticides have been set up at South Haven, Michigan, by Niagara Chemicals Division, Food Machinery and Chemicals. The unit will supply Michigan and Ohio with Niacide products for control of apple scab, Tedion dusts for mite control of fruits, and Thiodan compounds for insect control on vegetable crops. Operations are expected to begin in the spring of 1960.

Plans to expand manufacturing facilities at Sunolin Chemical, to include ethylene production, will bring eventual capacity to 200 million pounds a year. The $15 million plant at North Claymont, Delaware, will convert part of the ethylene to ethylene oxide and glycol to meet East coast needs. Dry gas from Sun Oil's Marcus Hook refinery will be used in production.

A newly established company, C-I-L Paints, will market the new enamel, Dynakote, in the United States. An oil-free baking finish based on a cross linked vinyl copolymer, Dynakote has many attributes of porcelain, yet does not require expensive vitreous enameling steel, nor the high temperature furnaces necessary for porcelain. Initial capacity of the American operation will be 250,000 gallons a year. Manufacturing facilities of the company, a subsidiary of Canadian Industries, Ltd, have been set up at the chemical plant of Arnold Hoffman in Cincinnati.

Research in hydride chemistry in the pulp and paper field is expanding "down under." Under a reciprocal 15 year research agreement between Australian Paper Manufacturers Ltd., Melbourne, and Metal Hydrides, U. S. firm, APM will investigate the use of hydrides in connection with pulp and paper technology. In turn, MHI will use its research facilities to develop API ideas commercially.

Chemical & Industrial Corp. and Chemetron's Girdler Construction have completed plans for a merger. C&I is best known as plant designer and builder for the fertilizer industry, while Girdler Construction is in the petroleum and chemical fields. According to present arrangements, Girdler Construction will function as a subsidiary of the Cincinnati firm. Chemetron is being compensated for the loss of its Girdler division with a "substantial minority interest" in C&I. No changes in top management are in the offing.

chemical feature

Explosion-proof lubricants

Halocarbons offer complete chemical inertness, high density, good lubricating properties for handling compressd oxygen, other corrosive chemicals

Burgeoning use of tonnage oxygen in the chemical and related industries, is giving a strong boost to halogenated lubricants—oils, waxes, and greases. These materials, originally developed during the World War II Manhattan Project, are finding ever greater application to the problems of handling not only compressed oxygen, but corrosives such as mixed inorganic acids, caustic solutions, oleum, red fuming nitric acid, halofluoride gases, hydrogen fluoride. Reason—chemical inertness, plus high density, lubricity, high dielectric strength.

The materials, which basically are saturated low-molecular-weight polymers of chlorotrifluoroethylene with the general formula $-(CF_2\text{-}CFCl)_n-$ are made by a controlled polymerization process, and are stabilized so that the terminal groups are completely halogenated and inert.

The polymerization product is then separated by vacuum distillation into several fractions:

Light to heavy oils with varying viscosities and pour points;

Low melting waxes which melt to high viscosity oils at high temperatures;

Greases, which are blends of various oil and wax fractions. At temperatures below the dropping or cloud point of the grease, the wax forms a thickener because of its low solubility in the oil, and imparts grease-like characteristics. Above the cloud point, the wax dissolves in the oil, adding to the viscosity and giving a material with good lubricating properties up to the maximum recommended temperature (about 500°F). The greases contain no thickening agents such as silicas, clays, soaps, or other non-halogens.

Explosion prevention

In tests for oxygen service, these compounds are said to have demonstrated:

- No spontaneous ignition in oxygen at 2,000 psig, at temperatures up to 440°C (824°F);
- No explosion in a pure oxygen atmosphere under an impact of 114 foot pounds;
- No oxygen pressure drop in the oxygen bomb test (Method 3453.1, Federal Specification VV-L-791e);
- No change in color when oxygen is bubbled through an oil for 24 hours at 160 and 300°F.

This inertness to oxygen makes these materials ideal for lubrication and sealing of shafts, valves, plungers, compressors in oxygen-handling equipment. Even above the cracking temperature of the compounds, the degradation products are likely to be of the type which would tend to extinguish flames. None of the breakdown products will support combustion.

Solubility

These materials will dissolve the halogens (except fluorine) and will dissolve volatile anhydrous inorganic salts, such as titanium tetrachloride.

Soluble in Lower Fractions	Insoluble in All Fractions
Acetone	Acetamide
Amyl acetate	Agar
Benzene	Aqueous solutions
n-Butyl alcohol	Anthracene
Carbon tetrachloride	Casein
Carbon disulphide	Cellulose acetate
Chloroform	Ethylene glycol
Dibutyl pthalate	Gelatin
Dioctyl pthalate	Glycerol
Dioctyl sebacate	Nitric acid
Ether	Nitrocellulose
Glacial acetic acid	Phenol
Hexane	Salicylic acid
Kerosene	Shellac
Methyl ethyl ketone	Sugar
Methylene chloride	Sulphuric acid
Mineral oil	Sulfonal
Silicone oils	Tartaric acid
Tetrachlorodifluoroethane	Thiourea
Trichloroethylene	Urea
Trichloromonofluoromethane	Water
Trichlorotrifluoroethane	

Effect on materials of construction

The chlorotrifluoroethylene oils, waxes, and greases have no adverse effect on polyvinyl alcohol or polysulfide elastomers or on Buna-N (butadiene-acrylonitrile), Hycar, Neoprene GN rubbers, or on Teflon and Viton polymers. However, within certain temperature ranges, they may have a deleterious effect on Buna S (butadiene-styrene) rubber, natural rubber, silicone rubbers, GRI (isobutylene-isoprene) rubber, and on copolymers of chlorotrifluoroethylene.

They wet metallic surfaces readily and form lubricating films in the same manner as the more common lubricants. They are non-corrosive toward metals at temperatures up to about 350°F, with the exception of copper and some of its alloys, which will discolor at temperatures over about 120°F. They are not recommended for aluminum thread applications, since chemical reaction between the oils and aluminum has been known to result in a detonation.

Blending properties

These compounds can be blended with other materials such as silicone oils, diesters, and other organic liquids to produce special lubricants, hydraulic fluids, and special liquid and wax preparations. They tend to improve non-flammability characteristics, increase density, and decrease water absorption. They will also blend well with silica-type grease thickeners to form greases for very high or very low temperature ranges. Blended with Teflon, graphite, asbestos fibers, and other materials, they can be important components in shaft packing materials and sealants. Dissolved in suitable halogenated solvents, some of the waxes can be applied as coatings for protection from corrosive fumes and vapors, and from oxidation.

Bromine variant

Newest development in this field are the polybromotrifluoroethylenes, identical organic polymers, halogenated with bromine instead of chlorine. Chemical and physical properties follow the same pattern as the polychlorotrifluoroethylenes, but their high cost has so far made them impractical for lubricant applications. They have, however, been found to be ideal flotation and damping media for gyro and accelerometer components in inertial guidance systems.

Note: Technical data by courtesy of Halocarbon Products Corp., Hackensack, N. J.

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- ☐ Preprint 1 - Heat Transfer Characteristics of Porous Rocks. I. Effective Thermal Conductivities of Porous Media Containing Stationary Fluid
- ☐ Preprint 2 - A Theoretical Analysis of Heat Flow in Reverse Combustion
- ☐ Preprint 3 - Conduction-Convection in Underground Combustion
- ☐ Preprint 4 - A Method of Measuring Thermal Diffusivities at Elevated Temperatures

TECHNICAL SESSION 6, PART I—JOINT A.I.Ch.E.-S.P.E.
- ☐ Preprint 26 - Miscible Displacement—Flow Behavior and Phase Relationships for a Partially Depleted Reservoir
- ☐ Preprint 27 - Miscible Fluid Displacement—Prediction of Miscibility
- ☐ Preprint 28 - Phase Relations of Miscible Displacement in Oil Recovery
- ☐ Preprint 29 - Laboratory Studies of Microscopic Dispersion Phenomena in Porous Media

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- ☐ Preprint 31 - Frequency Response from Non-Sinusoidal Waveforms
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- ☐ Preprint 43 - Effect of Pore Structure and Molecular Diffusion on the Mixing of Miscible Liquids Flowing in Porous Media
- ☐ Preprint 44 - Experiments on Mixing by Fluid Flow in Porous Media
- ☐ Preprint 45 - A Comparison of Propane and CO_2 Solvent Flooding Processes
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- ☐ Preprint 67 - Catalytic Cracking Feedstocks Derived from Middle East Crudes
- ☐ Preprint 68 - Catalytic Cracking Charge Stocks Prepared from Residues by the Gulf HDS Process
- ☐ Preprint 69 - Cat Cracker Feed Contamination—A Case History
- ☐ Preprint 70 - Characterization of Catalytic Cracking Stocks
- ☐ Preprint 71 - The Effect of Catalyst Metal Poisoning on Fluid Cracking Yields
- ☐ Preprint 72 - Processing of Feed Stocks for Catalytic Cracking

TECHNICAL SESSION 19, PART II
- ☐ Preprint 90 - Propane Deasphalting for the Production of Catalytic Cracking Feed
- ☐ Preprint 91 - Effects of Feed Boiling Range in Fluid Catalytic Cracking
- ☐ Preprint 92 - Use of Furfural Refining to Improve Catalytic Cracking Feed Stocks
- ☐ Preprint 93 - Preparation of Feedstocks for Catalytic Cracking
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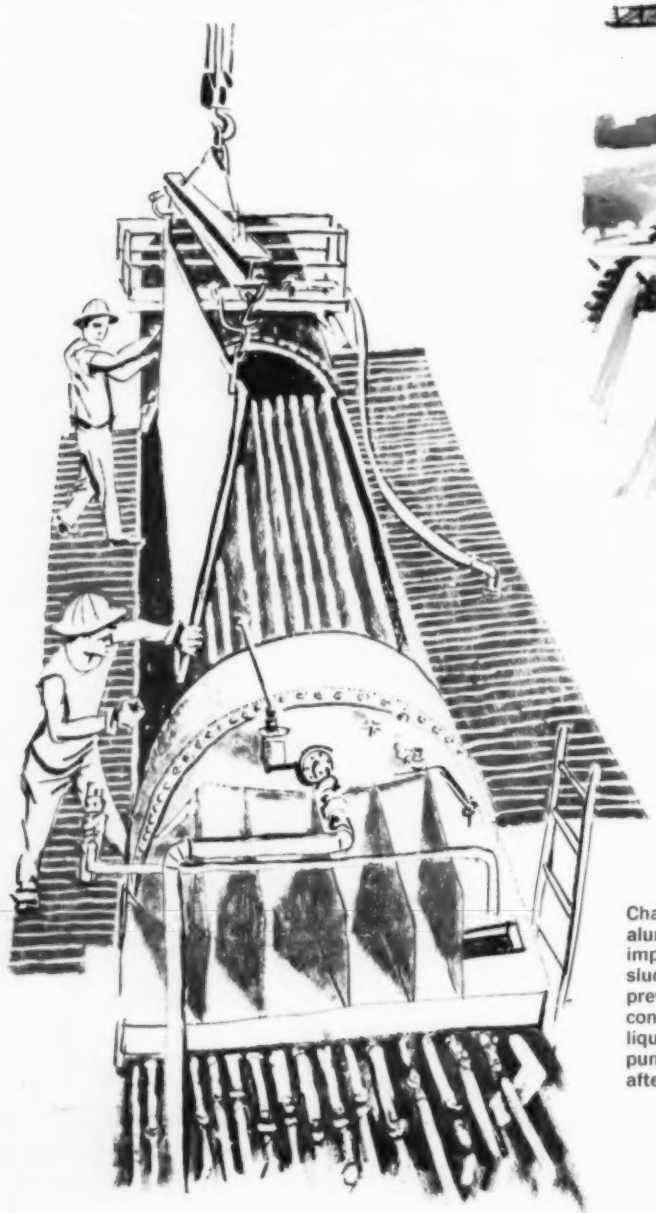
Alumina in Louisiana

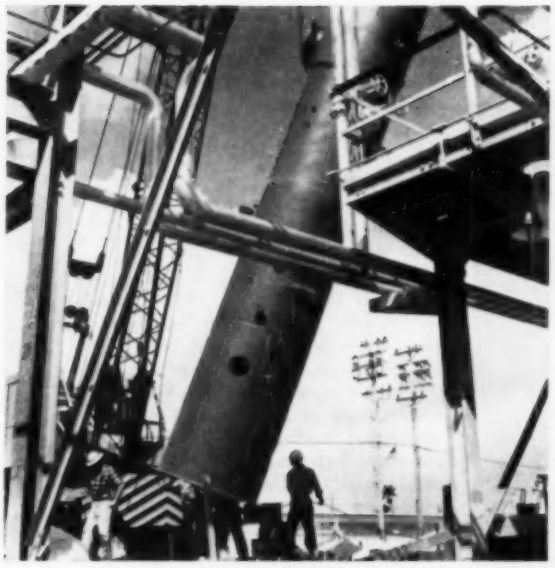
The world's most modern alumina plant, Ormet Corporation's at Burnside, Louisiana, is depicted in the drawings on this page by CEP's Art Editor, Paul Arlt. Alumina, chemically known as aluminum oxide, is the white powder from which basic aluminum metal is made.

After the filtration operation (below) the green liquor is pumped into one of 38 precipitators, vertical 80-ft. x 30-ft. diam. tanks, where aluminum trihydrate is added to "seed" the solution to precipitate larger particles of the same material.

At Burnside's deep water port facilities, brick red bauxite (aluminum ore) is unloaded from specially built ore ships. A unique vacuum unloading system is used to shift the ore out of the ship's hold to the giant gantry crane, and thence to a mile-long conveyor belt on which the material is carried to storage buildings inside the plant.



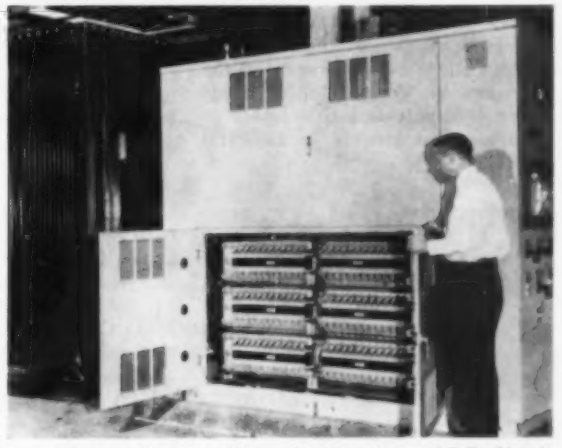
Changing the filter leaves of the bauxite (sodium aluminate) slurry filters. The filters screen out solid impurites called "red mud." The red mud is the sludge which did not dissolve in the digesters of a previous operation. The solution from the filters which contains the aluminum component is called "green liquor." After cooling in outdoor flash tanks it is pumped into precipitators (above). The red mud, after being washed, is pumped to a settling lake.



A tower is raised into position at Celanese's high-density polyethylene plant at Houston, Texas. The present expansion, slated for completion in March, will raise the capacity of the Houston plant to 50 million pounds per year.

Lab size fractionating column goes into operation in new chemical engineering building at Clemson College's just-dedicated Samuel Broadus Earle Hall, a gift from the Olin Foundation. Hard at work are R. A. Hensley and G. F. Lindabery, Clemson engineering seniors.

World's largest sheet of non-welded tantalum comes off the rolls of a cold mill at Kawecki Chemical, Boyertown, Pa. The new size sheet, 36 by 72 inches, is slated for fabrication of chemical processing vessels.



Large silicon rectifier, fabricated by I-T-E Circuit Breaker Co., is readied for shipment to Foote Mineral's Knoxville, Tenn., plant, where it will supply direct-current power for expanded production of electrolytic manganese.

people
in management
and technology

McAfee elected president of A. I. Ch. E. for 1960

Jerry McAfee will be 1960 president of A.I.Ch.E. it was announced at the 52nd National Meeting in San Francisco in December. McAfee is vice president—engineering in the manufacturing department of Gulf Oil, Pittsburgh, Pa.

After earning his BS from the University of Texas, and his ScD from MIT, McAfee joined Universal Oil Products in Chicago and spent the next four years as a research chemical engineer. He joined Gulf in 1945, at the Port Arthur refinery, and held several posts until elected vice president and director of research at Gulf Research and Development in 1954.

In 1955, McAfee was elected to his present post at Gulf. He is also a vice president of Venezuela Gulf Refining Company, and a director of Gulf Research and Development, Goodrich-Gulf Chemicals, Neches Butane Products, and Callery Chemical. In addition to his duties with Gulf, the incoming president is one of the U.S. representatives on the Permanent Council of the World Petroleum Congress, and was active in organizing the recent Fifth World Petroleum Congress in New York City. This year, he was selected a "Distinguished Contemporary Engineering Graduate" by the College of Engineering at the University of Texas. McAfee holds sixteen U.S. patents and is author or co-author of a number of technical papers.

Herman F. Mark of the Polytechnic Institute of Brooklyn, world authority on macromolecule chemistry, has won the 1960 William H. Nichols Medal of ACS's New York Section.

A contributor to knowledge of macromolecular structures, particularly in plastics, for over thirty years, Mark will receive the gold medal for research conducted and reported within the last five years. Professor of Organic Chemistry at Brooklyn Poly since 1942, Mark is also founder and director of the Polymer Research Institute. He is editor of the Journal of Applied Polymer Science, and editor and founder of the Journal of Polymer Science.

While a research chemist at Kaiser Wilhelm Institut, he helped confirm the existence of macromolecules, and in 1928 directed research for I. G. Farben. While professor of chemistry at the University of Vienna and director of the first Institute of Chemistry in that City, Mark and his assistants developed the mathematical basis of polymer science. After Hitler annexed Austria, Mark went to Canada where he became research manager of the Canadian International Paper Company. He has written eight textbooks and more than 500 scientific articles.

John Van Nostrand Dorr, Arthur K. Doolittle, Donald F. Othmer, W. George Parks and **William E. Rudolph** are the founding partners in a new firm of consulting engineers. Dorr Consultants, has been formed to provide engineering, financial, and management services to the chemical process, textile, and metallurgical industries. Dorr is honorary chairman of the board of Dorr-Oliver. Doolittle is president of the Arcadia Institute for Scientific Research, Othmer heads the Chemical Engineering Department at Brooklyn Polytech, and Parks is director of the Gordon Research Conference and head of the Chemistry Department at the University of Rhode Island. Rudolph is a civil engineer. Headquarters of the company are in New York City.

William A. Pennington has been installed as national vice president of the American Society for Metals. He is on the chemical engineering faculty at the University of Maryland.

Charles H. Davenport has been promoted to European technical representative for Monsanto. Headquarters are in Geneva, Switzerland, where he will be in charge of the Geneva office. Davenport replaces **David S. Weddell,** who returns to St. Louis as assistant director of development of Monsanto's overseas division. **W. D. Hill** will continue in the Geneva office.

Thomas P. Forbath moves over to the commercial development division, American Cyanamid, as general manager. He was formerly general manager, engineering and construction division.

Donato R. Telesca has been named vice president and general manager, International Metalloids plant in Toa Alta, Puerto Rico. Telesca was previously with Davison Chemical (W. R. Grace), Baltimore, Maryland.

In other staff changes at Monsanto, **Courtland M. Henderson** was appointed group leader, Research Department, Dayton, Ohio. **Robert C. Johannsen** was assigned to the Purchasing Department, William G. Krummrich Plant, Monsanto, Illinois.

Frederic A. Soderberg was appointed general manager, Huyck Felt Company Division, F. C. Huyck & Sons. Soderberg is vice president of the parent firm.

J. H. Reifel has been made director of the newly established Corporate Development and Planning Division, Wyandotte Chemicals. The long time company executive was previously director, engineering and development.

Robert K. E. Whitaker has opened a consulting office in Sydney, Australia, where he will act as a project engineer. Whitaker was until recently employed at Universal Oil Products, Des Plaines, Illinois.

Malcolm H. McAllister has been appointed vice president of Vitro Chemical, new Vitro subsidiary. He will continue as president of Berkshire Chemicals, sales subsidiary distributing foreign and domestic industrial chemicals to U.S. industry.

Clarence Thom takes over as consulting metallurgist for Denver Equipment. Thom, for twenty-five years director of the company's Ore Testing Division, has his offices in Denver, Colorado.

Recently elected an officer of the Columbus Technical Council is **George F. Sachsel.** Sachsel, who is at Battelle Memorial Institute, is a past chairman of Central Ohio Section.

W. S. Vorhaben has returned to Humble Oil & Refining from military service. He is at the Baytown, Texas refinery.

MARKETING

Edgar L. Demarest has rejoined Blaw-Knox Buflovak Equipment Division as Eastern District manager of the Buflovak office at Haddon Heights, New Jersey.

Benjamin M. Holt has been named sales manager for Southwestern Engineering, engineering and construction division. Holt has more than 20 years experience in sales and engineering management, including work with American Potash, and Union Oil of California.

Lloyd C. Cooley has joined the Ross Engineering organization. He is sales representative for Hungerford & Terry, in the Chicago and northern Illinois area.

L. Neil Brown has been added to the midwest sales staff of Nichols Engineering & Research. He will work out of Indianapolis, Indiana.

NECROLOGY

Walter J. Murphy, 60, editorial director of the American Chemical Society's applied journals. Widely recognized as one of the chemical industry's leading spokesmen in this country, Murphy was also director of ACS's News Service. Last summer, he made a six week tour of European chemical meetings, and was the first American to address the board of directors of the German Chemical Manufacturers Association. After World War II, he went to Germany for the Joint Chiefs of Staff to investigate wartime developments in the German chemical industry, and was later influential in the establishment of the Office of Technical Services.

Murphy entered the editorial field in 1930, as managing editor of Chemical Markets (later Chemical Industries) after several years as a chemist in industry. He was named editorial director of the applied journals in 1955. By then, these included C&E News, Industrial & Engineering Chemistry and Analytical Chemistry (made into a separate monthly under his direction), and the Journal of Agricultural and Food Chemistry (established in 1953 under Murphy's editorship). Added to these was the Journal of Chemical and Engineering Data and the international edition of Industrial and Engineering Chemistry.

Murphy was author or co-author of several books, including a diary reporting day-by-day developments at the Bikini atom bomb tests in 1946, where he went as a technical representative.

local sections

Separation processes in spotlight at Central Virginia one-day meeting

Newer separation processes was the theme of the Meeting-in-Miniature held by the **Central Virginia Section** (*Robert M. Hubbard*), in October. The subject was well covered in the six paper technical meeting at the University of Virginia. A quick run-down on the sessions shows:

Pilot Scale Equipment for Continuous Ion Exchange and Solvent Extraction, I. R. Higgins, Chemical Separations Corp., and **J. T. Roberts,** Oak Ridge, described the Higgins contactor and some of its applications. Pulsed column and mixer settlers, widely used by AEC, were demonstrated in flow sheets.

Ion Exchange Separations, N. W. Frisch, Rohm and Haas, gave a brief description of basic types of ion exchange separation processes, with specific industrial applications involving them.

Recent Developments in Industrial Separations by Ion-Selective Membranes, Carl Berger, Ionics, took up the foremost among the newer developments, including reduction processes, concentration of radioactive compounds, concentration of salts from sea water and their removal from starch hydrolysis.

Separation Processes Involving a Chelate Resin, L. J. Lefevre, Dow. The affinity of this newly developed resin for heavy metal cations allows separation of closely related heavy metals, such as cobalt and nickel, and copper and nickel, at relatively fast flow rates. Metals can even be removed from solutions saturated with alkali or alkaline earth metal cations.

Ultra Pure Argon Atmosphere Control, L. S. Gaumer and G. Fedorco, Air Products, describes a low temperature process for purification of an argon atmosphere in a sealed room where metallurgical operations are performed upon highly reactive metals. The process includes a catalytic reactor for conversion of oxygen to water, removal of water and hydrocarbons by adsorption, and removal of nitrogen by low temperature distillations.

Separation of Olefinic and Acetylinic Hydrocarbons Using Dimethyl Formamide, J. W. Riggle and G. W. Holtzlander, Du Pont. Data was presented for the solubility of acetylene, methyl acetylene, methane, ethane, ethylene, and 1-butene at -40°C, 20°C

continued on page 144

CLASSIFIED SECTION

Address Replies to Box Number care of:
CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36, New York

SITUATIONS OPEN

Medium size integrated oil company located in Texas has openings for qualified professional personnel. This is a fast growing company offering advancement opportunities to capable men. Please send resume including references, recent photograph and salary required to Box 2-1. Replies are strictly confidential and our employees know of this advertisement.

CHIEF PROCESS ENGINEER
Graduate chemical engineer with minimum seven years refinery experience covering process design and economics.

SENIOR MECHANICAL ENGINEER
Graduate mechanical engineer with minimum four years refinery or plant experience. Experience in plant maintenance and preferably some experience in design.

SENIOR PROCESS ENGINEER
Graduate chemical engineer with minimum four years refinery or refinery design experience. Should include plant technical services.

JUNIOR PROCESS ENGINEER
Graduate chemical engineer. No previous experience necessary.

MATHEMATICIAN OR COMPUTER PROGRAMMER
Bachelor of Science graduate with educational emphasis on mathematics or physics, preferably both. No previous experience necessary.

SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL/INDUSTRIAL ENGINEER—Graduate degrees. Age 30. Eight years' diversified experience in chemical and allied industries, U. S. and abroad. R & D, design, economic analysis, commercial-technical liaison, market research, process engineering, project administration. Desire responsible position in process/commercial development, preferably N.Y.-N.J. or foreign. Will consider relocation. Box 6-1.

PLANT MANAGER OR PROJECT MANAGER—Aggressive, hard hitting, M.S.Ch.E. with twenty years' of plant management, construction-engineering project management, process engineering management. Experience in petroleum, fermentation solvents, pharmaceuticals, fine chemicals, synthetic organics, high-energy fuels, dyestuffs. P.E. Box 7-1.

CHEMICAL PROJECT ENGINEER—Over fifteen years' experience systems design and project engineering in chemical plants, oil refineries, petrochemicals and presently nuclear power plants. Management or staff. New York metropolitan area preferred. Box 8-1.

EXPERIENCED ENGINEERING AND MANAGEMENT EXECUTIVE—Thirty years' supervisory and executive positions with two major companies in production, planning, purchasing, construction and product development. Limited foreign experience. Box 9-1.

B.Sc., PHYSICS, LONDON, ENGLAND—36; ten years' with leading American and British oil companies. Diversified process development, scale up, and design. Refinery troubleshooting. Would like similar work anywhere in U.S. Box 10-1.

CHIEF ENGINEER, PLANT ENGINEER, MANAGEMENT—Age 42, with eighteen years' broad experience. At present supervisor of construction, procurement, water, wastes, steam, air conditioning, etc., at large plant. Experienced in planning, processing, costs reduction, economics, insurance, contracts, development, etc. Florida or South. Box 11-1.

(continued on page 138)

ENGINEERS

EXTREME LOW TEMPERATURE INTRODUCES CHALLENGING PROBLEMS FOR CREATIVE ENGINEERS

LOW-TEMPERATURE PROCESSING

0°F

460°F

PROCESS ENGINEERS . . .

Several positions available for chemical engineers with 2-5 years' experience in process engineering of chemical, petrochemical or petroleum refining plants. Strength should be in the areas of unit operations, heat transfer, thermodynamics, distillation and fluid flow. Positions cover process engineering performed for sales proposals and final plant design, for operating and process improvement of existing plants as well as for developmental process engineering.

ESTIMATING ENGINEERS . . .

Several positions available for ChE's or ME's with 2-5 years' experience in the process industry in process, design or operations of which 2 years should be in appropriate estimating or economics experience. Duties include determination of material and equipment needs, equipment arrangements, process suitability, process or component economics or cost data. Cost estimates will cover total costs of equipment, plants or products to be sold or furnished by the company. Individual must be able to deal effectively with all engineering levels.

SALES PROPOSAL ENGINEERS . . .

Our expanding sales activity requires the addition of several ChE's or ME's to prepare technical sales proposals and economic evaluations. Responsibilities include liaison and close coordination between the Sales Departments and the Engineering, Manufacturing, Operations and Financial Departments as well as top management. These positions will be filled by individuals with 0-5 years' experience in a staff sales capacity or who are currently employed in the chemical, petroleum or related industries. *Unusual and exceptional opportunities for those interested in sales engineering or sales administrative functions and responsibility.*

Air Products OFFERS:

- Outstanding corporate growth record thus creating new opportunities for individual growth.
- Substantial backlog of orders and future prospects present advancement opportunity.
- Broad market diversification including basic steel producers, chemical, petrochemical, refinery, natural gas and defense customers.
- Company develops, designs, manufactures, constructs and operates its own equipment.
- Location: suburban living yet near Philadelphia and New York for metropolitan advantages. Excellent school and recreational facilities.
- Liberal benefit program including tuition refund.
- Well evaluated salary program. • Relocation paid.

Please send resume to E. J. Strobel, Technical Personnel Manager, Dept. 536.

Air Products ...INCORPORATED

P. O. BOX 538 ALLENTOWN, PA.

TECHNICAL DIRECTOR

Chemical Engineer with administrative ability to handle interplant technical correlations. Plan and direct experimental research problems in our East Texas plant.

Send detailed resume to:

PERSONNEL DEPARTMENT

THIOKOL CHEMICAL CORP.

Marshall, Texas

URANIUM-VANADIUM MILLING POSITIONS

Mechanical, Chemical and Extractive Metallurgical Engineers and Chemists with good qualifications and 0 to 6 years of experience to work in Colorado Operations. Locations: Rifle and Uravan. Send resume and copy of college transcript to:

Union Carbide Nuclear Company
Division of Union Carbide Corporation
Post Office Box 1049
Grand Junction, Colorado

ENGINEERS CHEMICAL

Employment in SAN FRANCISCO, CALIFORNIA

Graduate engineers with 3 to 10 years applicable experience in process or project design work in refinery, petrochemical, or chemical fields.

Liberal relocation allowance for you and your family.

Send confidential resumé to:
GEORGE I. COPELAND,
Manager of Personnel

BECHTEL CORPORATION
220 Montgomery Street
San Francisco, California

NUCLEAR
REACTOR DESIGN & DEVELOPMENT
(and other openings)

See Pages 22-23

GENERAL ATOMIC
Division of GENERAL DYNAMICS

(continued from page 137)

CHEMICAL ENGINEER — B.Sc.Ch.E., 1942. Seventeen years' experience, process, job and sales engineer for petroleum refineries and petrochemical plants. Perfect German, some Dutch and Russian. Now senior project engineer in Germany. Desire senior position overseas with engineering or oil company. Box 12-1.

CHEMICAL ENGINEER—B.S., B.Ch.E., age 30, veteran, family. Over three years' experience petrochemicals; technical service, process design. Desire challenging position where company and personal growth can be mutual interests. South, Southeast preferred, others considered. Box 13-1.

CHEMICAL ENGINEER—B.Ch.E. 1950, age 32. Nine years' varied experience petroleum refining units operation, process supervision, plant startup, operator training, product analysis. Desire technical service or process engineering position offering professional growth. Box 14-1.

CHEMICAL ENGINEERING EXECUTIVE—Former plant engineer, director of engineering. Staff positions to top management. Versatile, broad background. Strong in Economics, Human Relations. M.S.Ch.E. Eighteen years' experience. Now in east. Present salary $13,500. Box 15-1.

CHEMICAL ENGINEER—B.S.Ch.E. Age 33, family. Six years' marketing experience in organic and inorganic chemicals. Desire challenging position in field sales. No location preference. Box 16-1.

PROCESS DEVELOPMENT ENGINEER—B.S.-Ch.E., P.E., age 26. Six successful years in process engineering and development work involving unique inorganic processes. Desire challenging position with R & D organization. Prefer Northeast quarter of U.S. Box 18-1.

SITUATIONS WANTED

CHEMICAL ENGINEER—B.S.Ch.E., twenty-five years' experience in fine and heavy chemical manufacturing. Includes responsible production and development management. Interested in management or administrative position in chemical or allied industries. Salary $14-16,000. Box 20-1.

CHEMICAL ENGINEER—B.S.Ch.E. 1953, MBA 1959. Four years' experience in research and development, process design, economic evaluation, equipment selection, project management and coordination. Seek challenging position in management liaison with executive potential. Minimum salary: $9,000. Box 21-1.

CHEMICAL PETROLEUM ENGINEER— (BS both) 28, single, three years experience Reservoir Engineer, two years' varied. Desire change. Domestic or foreign. Fluent Spanish. Box 22-1.

CHEMICAL ENGINEER—Ten years' diversified experience in process and project design, R & D, and economic evaluation in petroleum and petrochemicals. Desire eastern location. Present salary $11,400 per month. Box 23-1.

PROCESS ENGINEER—M.S.Ch.E. plus one complete year additional graduate study. Twelve years' petroleum and petrochemical process and project design experience with emphasis on all phases of ethylene production and light hydrocarbon processing. Experience includes successful plant startup of these units. Desire responsible process-project position in petroleum or petrochemical design. Box 24-1.

(continued on page 140)

SITUATIONS WANTED

(continued from page 139)

CHEMICAL ENGINEER—B.Ch.E., P.E., age 32. Nine years' process development, production supervision and plant engineering in organic chemicals. Desire plant management or greater responsibility in plant engineering and maintenance in small to medium company. Box 25-1.

INDUSTRIAL MANAGER—B.Ch.E., P.E., and graduate work, capable of making decisions and assuming responsibility, used to working under pressure, desire management level position with future, salary $13,500. Box 26-1.

TECHNICAL WRITER—B.Ch.E., 1952. Desire technical and/or general writing assignments, Oklahoma City-Tulsa area. Three years' marketing (instrumentation), two years' process engineering (oil, overseas), two years' free lance writer. Box 28-1.

B.S.Ch.E.—completed graduate studies, Tau Beta Pi, age 38, family, veteran. Nine years' experience production, R & D, process evaluation and control, process improvement, equipment design, pilot plant supervision. Prefer Maryland, Delaware area. Box 29-1.

CHEMICAL ENGINEER—B.S. 1953, veteran, five years' experience in organic oxidation and purification process engineering, start-up and design review. Interested in Production Supervision in South or East. Box 30-1.

SPACE R & D WANTED—MIT '47, B.S. Chem. Eng., Army engineer; twelve years' diversified R & D assignments: organic, inorganic, oxidation, high temperature, metallurgy, process design and liaison. Age 37, $12,000; exact, conscientious, imaginative. Rocket propulsion test or development preferred. Box 31-1.

BUSINESS—Chemical engineering background in petroleum, synthetic fibers, carbon black, liquid rocket fuels. Strong in design, development, administration. Desire small or medium-sized company. M.S.Ch.E. 1950, M. I. T. Minimum $12,000. Box 32-1.

(continued on page 144)

ENGINEERING SOCIETIES PERSONNEL SERVICE, INC.

(Agency)

New York	Chicago	San Francisco
8 West 40th St.	29 East Madison St.	57 Post St.

These items are listings of the Engineering Societies Personnel Service, Inc. This Service, which cooperates with the national societies of Chemical, Civil, Electrical, Mechanical, Mining, Metallurgical and Petroleum Engineers, is available to all engineers, members and non-members, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5% of the first year's salary if a non-member, or 4% if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number.

When making application for a position include eight cents in stamps for forwarding application to the employer and for returning when possible.

A weekly bulletin of engineering positions open is available at a subscription rate of $3.50 per quarter or $12 per annum for members, $4.50 per quarter or $14 per annum for non-members, payable in advance.

Positions Available
New York Office

PROCESS ENGINEER, graduate chemical, 28-50, with a minimum of five years' experience in plant design and process evaluation in gas treating and low temperature processes. Salary, $8000-$10,000 a year. Location, Midwest W-8346.

PRODUCT MANAGER, degree in chemical or mechanical engineering, but possibly in forestry, with about five years' experience to include a wide acquaintance among people in the lumbering, saw mill and wood working trades. Selling experience such as with a manufacturer of equipment used by these industries. Duties will include supervising and programming of the promotion and sale of charcoal retorts. Salary open. Location, New York State. W-8315.

SALES ENGINEERS. (a) Application Engineer, preferably chemical or mechanical engineering graduate, with a minimum of two years' experience in application, product, sales or related engineering field, to determine suitability of company equipment to customer requirements, specify type of equipment and accessories needed to meet customer requirements, etc. Salary, $6000-$7000 a year. (b) Sales Engineer, chemical graduate preferred, with one to two years' engineering sales, application engineering or product engineering, but will consider recent graduate. Will handle customer contacts re: Applications, product functioning, pricing, modifications and delivery of vacuum pumps and compressors, etc. Salary, $6000-$7000 a year. Location, Conn. W-8284.

CHEMICAL ENGINEER, recent graduate, to work in New York for a few months training. Will go to Peru, S. A. on development of an alkali project on a three-year contract. Salary, $5400 a year plus housing. Knowledge of Spanish helpful. F-8252.

CHEMICAL ENGINEERS. (a) Junior Chemical Project Engineers, graduates, to assist in economic analysis of chemical processes; calcualte material and energy balances; assist in preparation of flow sheets, etc. Salary, to $7000 a year. (b) Chemical Project Engineers, graduates, with five to eight years' experience, to perform process design engineering involving economic analysis of processes, material and energy balance calculations, preparation of flow sheets, sizing and selection of equipment for engineering and construction of heavy chemical plants. Salary, to $10,000 a year. (c) Research and Development Engineers, graduate chemical, with five to eight years' experience in process development problems. Will develop modifications of company processes and design test equipment; carry out planned research and development programs, etc. Salary, to $10,000 a year. Submit detailed resumes including current earnings and salary requirements. Company pays placement fees. Location, New York, N. Y. W-8232.

CHEMICAL ENGINEERS OR CHEMISTS, graduates. (a) One for research and development work in building paper, mineral wool field, to 45, with four to five years' direct experience in building paper, mineral wool fields; knowledge of glass fibers helpful. Will do research and development of new products; customer contact to introduce new products and/or develop solutions to special problems. Salary, about $10,000 a year. Some travel. (b) One for research and development work on asphalt roofing and siding, with two to three years' experience in asphalt field with building materials or oil refining industry. Will work as assistant on research and development projects relating to asphalt roofing and siding. Salary, to 7000 a year. Location, New Jersey suburban area. W-8230.

CHEMICAL ENGINEERS, graduates, with about seven years' experience in petroleum refining industry, with good backgrounds in petroleum refining technology and economics, for laboratory which provides technical and professional services to petroleum refiners. Location, Midwest. W-8225.

SENIOR RESEARCH ENGINEER, 30-40, Ph.D. in chemical engineering, with five years' experience in heat and mass transfer fluid flow and high vacuum, to design, build and operate pilot plant to produce material for consumer and market tests for various products such as fruit, vegetables, etc. Determine the needs, material cost and general economics of a commercial size unit and be able to set it up. Salary, $9000-$10,500 a year. Location, Midwest. W-8123.

Chicago Office

SALES TRAINEE, graduate mechanical or chemical, to 30; initial duties will include running chemical tests in company's filtration laboratory. This will be followed by various field trips to gain first hand knowledge of customer's filtration problems. After a year or two should be able to be assigned to permanent sales and service duties for a manufacturer of filtration equipment. Salary, $6000-$7500 a year. Company pays placement fee. Location, Illinois. C-7823.

CHEMICAL ENGINEERS AND CHEMISTS, M.S. and Ph.D., with none to considerable experience in one of the following: Catalysis, surface chemistry, colloid chemistry, solution chemistry and high temperature technology; solid state chemistry; instrumental or classical chemical analysis; fine particles; proteins and carbohydrates; synthetic inorganic chemistry research; process engineering; ammunition development for a research organization. Salary, $6600-$10,800 a year. Employer will negotiate placement fee. Location, Illinois. C-7812(b).

San Francisco Office

PAINT CHEMIST, chemical engineering graduate or chemist, with at least five years' experience in paint industry, for development work under chief chemist. Salary, about $6600 a year to start. For a large company. Location, San Francisco. SJ-4906.

ASSISTANT ENGINEER, chemical or mechanical graduate, recent graduate or one year or so experience, to assist senior engineers in analyzing performance data, following on field equipment performance, assisting in design and installation of heavy maintenance and participating in regular plant engineering and new construction program. Salary, about $5400 a year. For a petro-chemical company. Location, San Francisco East Bay. SJ-4906-R.

RESEARCH AND DEVELOPMENT ASSISTANT, chemical engineer, chemist or food technologist, to 40, to assist head of research department in analyzing, making extensive and detailed reports on all phases of sugar processing and usage. For manufacturer. Salary commensurate with experience. Location, Sacramento Valley, Cal. SJ-4906.

CHEMICAL ENGINEER, graduate, under 40, with substantial experience of several years' in fossil fuels, petro chemicals or coal research. Capable of carrying on responsible work with minimum of supervision; primarily concerned with coal research in connection with expansion in steam electric generating facilities. Could involve any other investigation in which research department may become involved. Some travel. Salary, $7200 for minimum qualifications; $9600-$10,800 for exceptionally qualified man, plus fringe benefits. For a public utility. Location, Pacific Northwest. SJ-4895.

SENIOR RESEARCH CHEMIST, B.S. or M.S. in chemical engineering or chemistry. Minimum of ten years' experience and proven record of development in precision molded rubber products. Compounding experience should include extensive development work at senior level in rubber and synthetic rubber materials and bonding of rubber to metal. Experience should further include production problems of rubber molded products. Will carry out applied research as directed; reports to chief chemist. Location, San Francisco Peninsula. SJ-4886.

RESEARCH ENGINEER, chemical engineer or chemist, 25-35, with two to ten year's experience in plant control and products research and development related to pulp and paper. Particular interest in coatings for paper board manufacture. Salary commensurate. Location, San Francisco East Bay. SJ-4881-R.

RESEARCH ENGINEER, M.S. in chemical or metallurgical engineering or chemistry, or B.S. with exceptionally strong research experience, under 40. Must be interested in applying knowledge to solution of industrial problems rather than to fundamental research. Department conducts applied research and development on new processes and major process improvements in fields of mineral beneficiation, hydrometallurgy and pyrometallurgy. Salary commensurate with training and experience; liberal fringe benefits. Location, West. SJ-4876-R.

JUNIOR CHEMICAL ENGINEER, graduate, one or two years out of school, to enter into all-around engineering training program at level appropriate to experience; enter manufacturing department at refinery and actively participate in integrated program involving laboratory, process assignment located in San Francisco Bay area or Los Angeles area. Salary commensurate, with credit for experience. Pacific or Mountain States residents only. SJ-4871-R.

PROCESS ENGINEER, chemical or mechanical graduate, 28-40, with a minimum of three or four years' experience in cement or similar work, knowledge of factory and understanding of instrumentation. Will work as process engineer developing improved processes in connection with operating personnel. For cement company. Salary, $7200 a year, up. Location, central California Coast. SJ-4869.

TO THE EXCEPTIONAL ENGINEER WITH MANAGEMENT POTENTIAL . . . WHO WANTS TO MOVE UP FASTER

One of the World's Leading International Engineering Organizations, Located in the New York Metropolitan Area, Now Offers Unexcelled Growth Opportunities With Its Staff of High Level Engineers.

DOES THIS DESCRIBE YOU?

. . . You're a graduate Chemical Engineer with a Master's Degree or graduate courses.

. . . You have had about 5 years experience in process design, either in the petroleum or petrochemical field.

. . . You have optionally had 1 to 2 years' experience as an operator.

. . . You are currently with an oil refining or petrochemical company, or contractor.

. . . You are dissatisfied with compartmentalized work, feel stymied, and desire stimulating variety in your career.

. . . You are intelligent enough to call on the specialized knowledge of others, resourceful and tactful enough to use your own initiative, and mature enough to know when to do which.

IF SO . . .

You may possess the right qualifications for this unusual opportunity. (Two men will be selected at this time.) If selected, there will be a brief orientation period. You will then be associated with a high level staff group engaged on a wide variety of projects. You will enjoy outstanding working conditions as well as liberal benefit plans.

TO APPLY . . .

Write promptly, enclosing a resume, or description of your personal background, scholastic record and professional experience. State your earnings history and salary desired. All replies will be held in *strict confidence.*

ADDRESS BOX NO. 5-1

PROJECT ENGINEER

Ch E or M.E.

An opportunity to complete the development of a new line of paper & paper board products for the packaging field & to build new facilities for their production.

Acceptable applicant must have a degree in Chemical or Mechanical Engineering plus 10 years experience in process industries, including development, project engineering & production supervision-with some experience in film or paper coating, laminating & finishing operations.

Submit detailed resume including salary requirements to—Director of Personnel

STANDARD PACKAGING CORPORATION

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CHEMICAL ENGINEERS

Recent graduates in chemical engineering and engineers with several years' experience are needed for challenging research positions in our expanding Central R & D Organization.

These positions embrace—pilot plant design, construction and operation—economic analysis of new processes—engineering studies including newer disciplines of statistical analysis, operations research and computers.

Our Laboratories, located in Suburban Phila., are modern and well equipped and our personnel policies are liberal including substantial educational assistance.

WRITE

PENNSALT CHEMICALS CORP.

P. O. Box 4388, Phila. 18, Pa.

SENIOR PROJECT ENGINEER 30-42: Chemical Engineering degree with 5-10 years supervision of petro-chemical or chemical plant design, installations and equipment changes. Must be able to make process calculations and have some experience on project cost control. Individual must have ability to be compatible with people and have desire for advancement. Salary to $8,000 depending on experience. Box 1-1.

CHEMICAL ENGINEERS (3-5 YEARS EXPERIENCE) INSTRUMENT APPLICATIONS (PROCESS) DESIGN & ESTIMATING (PILOT PLANT)

These are permanent positions in the Technical Division of a stable, medium-sized, midwest company engaged in research and development on industrial organic chemicals. Modern facilities, suburban living, excellent employee benefits. All replies will be acknowledged and kept confidential. Box 3-1.

CHEMICAL ENGINEERING APPOINTMENT:

McMASTER UNIVERSITY

The Department of Chemical Engineering solicits applications for a staff position in a new school with a stimulating research environment.

Facilities include: new research laboratories, a one-megawatt nuclear reactor, digital computer, and an extensive stock of research instruments and devices.

Duties of the position: lecturing in transfer operations at undergraduate and graduate level, supervision of undergraduate design projects, and direction of graduate research.

Qualifications and rank: The candidate should have a doctorate in chemical engineering and experience in lecturing and in research direction. Initial appointment at the rank of associate professor is contemplated. Enquiries and the names of three references should be addressed to:

Dr. J. W. Hodgins, Chairman,
Department of Chemical Engineering,
McMaster University
Hamilton, Ontario

Classified . . . EQUIPMENT SECTION

$3,000,000 LIQUIDATION

CHEMICAL PLANT—Orange, Texas. Type 316 stainless steel reactors, tanks, heat exchangers, columns, pumps, crystallizers, etc.

Send For List

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Here's really something to toot about—

GELB

CHEMICAL PROCESS EQUIPMENT

2—Pfaudler 750 gal. glass lined jacketed reactors
9—Davis Engineering SS heat exchangers 145 sq.ft. (NEW)
1—Shriver aluminum 30"x 30" plate and frame filter press, 30 chambers
2—Fletcher 40" suspended type rubber lined centrifuges with perforated baskets and motors.

AUTOCLAVES KETTLES AND REACTORS

2—Horizontal stainless steel 3000 gal. storage tanks
1—Steel and Alloy Tank Co. 100 gal. type 347 SS pressure tank, 250 psi jacket
1—Blaw-Knox 400 gal. steel jacketed autoclave. 570# internal pressure, 85# jacket
1—Blaw-Knox 45 gal. jacketed autoclave, 1500# pressure
1—Process Engineers SS jacketed reactor, 1500 gal., 140# W. P. jacket, 150# W. P. shell
1—Steel & Alloy Tank Co. SS jacketed tanks, 500 gal. each
2—Pfaudler 200 gal. glass lined reactors with impeller type agitators and drives
1—Pfaudler 500 gal. glass lined jacketed reactor, complete with impeller type agitator, baffle and drive.
1—Pfaudler 50 gal. glass lined jacketed reactor complete with agitator and drive
1—Edgemoor type 316 SS gal. jacketed reactor
1—Struthers Wells 500 gal. nickel jacketed reactor
1—Patterson-Kelley 600 gal. steel jacketed reactor, 40# jacket, complete with agitator and drive
1—Patterson 2000 gal. steel jacketed reactor
2—Haveg 300 gal. pressure vessels complete with agitators and drives
28—30,000 gal. steel vertical storage tanks

DRYERS

1—Link Belt steel roto louver dryer, Model 1003-30
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
2—Stokes Model 138J-20 single door vacuum shelf dryers, 20 shelves, complete
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
1—Buflovak SS rotary vacuum dryer, 3' x 15'
1—Stokes double drum dryer, 5' x 12'
1—Louisville rotary steam tube dryer, 8' x 45'
2—Louisville SS rotary dryers, 8' x 50'
1—Louisville SS rotary kiln, 30" x 28' complete
1—Louisville Rotary Dryer, 38" x 40' Type L
1—Ruggles Coles 4' x 30' rotary kiln
1—Traylor 4' x 40' rotary dryer
1—rotary dryer 6' x 36'

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
1—Sweetland #3 stainless steel filter
1—Niagara SS filter, Model 510-28
1—Oliver horizontal filter, 3'
10—Shriver plate and frame filter presses, 12" to 42"
1—Shriver C.I. plate and frame filter press, 36" x 36" closed delivery, 4 eye, 60 chambers
1—Shriver rubber line filter press, 36" x 36"
12—Sweetland #12 filters with 72 SS leaves

CENTRIFUGES

1—Tolhurst 40" SS suspended type centrifuge complete with plow and motor with imperforated basket
1—Tolhurst SS 20" suspended type centrifuge with perforated basket, complete with plow and motor
1—AT&M 26" suspended type centrifuge with SS perforated basket, complete with plow and motor
1—AT&M 48" SS suspended type centrifuge, complete with plow motor and imperforated basket

THE GELB GIRL—JANUARY 1960

1—Bird type 316 SS centrifuge 32" x 50"
4—Tolhurst 30" center slung rubber covered centrifuges with perforated baskets and motors
18—Sharples SS centrifuges, Model 16Y

MIXERS

15—Robinson type 304 SS horizontal blenders, 225 cu. ft. each
3—Robinson type 316 SS sigma blade jacketed heavy duty mixers, 400 gal.
1—Baker Perkins Size 16 Type UUEM 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
2—Sturtevant #7 dust type rotary batch blenders, NEW
1—12' x 4' pug mixer, type 316 SS
1—Patterson type 34 75S jacketed vacuum sigma kneader master, 500 gal.

MISCELLANEOUS

1—Cleaver-Brooks 500 HP package steam generator, 200#
2—Cleaver-Brooks package steam generators, 50 & 80 HP, 125#
2—Heat Transfer Products steel bubble cap columns, 36" and 42' with 5 and 10 trays
1—Acme steel bubble cap column, 42" dia. with 10 trays
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Vulcan SS bubble cap column, 4' x 28 plates
2—Patterson-Kelley steel heat exchangers, 1000 sq. ft. each
6—Struthers Wells heat exchangers, 885 sq. ft.
1—Patterson-Kelley steel heat exchanger, 427 sq. ft.
50—Steel heat exchangers from 15 sq. ft. to 400 sq. ft.
1—Downington type 136 SS heat exchangers, 750 sq. ft.
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 sq. ft. and 600 sq. ft.
3—Robins shaker screens, SS, 3' x 6'
1—Swenson type 316 SS vacuum crystalizer 3'6" x 12'
1—Swenson type 316 SS vacuum crystalizer, 2' x 12'
1—Blaw-Knox steel distillation column, 36" x 40' with 24 trays, (NEW)
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75 ANNIVERSARY

local sections

from page 136

and 100C in dimethyl formamide. Indications were that this solvent can be used for selectively separating acetylenic from olefinin hydrocarbons in an absorption process. Also given were mathematical techniques for correlating and thermodynamically validating the data. Procedures and equipment used in measuring the data were described.

Special metals

The use of organic solvents to obtain highly refined material for special purpose metals appears to be warranted only when there is no other economical means to achieve the desired purity, is the opinion of R. B. Filbert, chief of chemical engineering research at Battelle Memorial Institute. Occasion was the November meeting of the **Philadelphia-Wilmington Section,** (*Paul D. Birkhahn*), held at Philadelphia. While normal industrial interest in extraction processing has been in the removal of organic materials from mixtures, recent innovations have been those associated with the removal by organic solvents of inorganic salts from mixtures. Present day technology is based on the fact that uranium salts could be extracted by organic solvents. And, also, upon knowledge gained during the atomic bomb program in the 1940's, when 30 tons a month of pure uranium oxide was produced by this technique to be used as nuclear fuel. The need for pure material is just as important today, considering the fact that even small amounts of trace materials in metals required for the fabrication of rocket motors, nuclear reactors, transistors, and high temperature purpose capacitors, has pronounced effects.

George B. Kistiakowsky, special assistant to President Eisenhower for Science and Technology, addressing the A.I.Ch.E. New York Section meeting on December 2.

Also meeting

William S. Dougherty talked on selling management a fully instrumented process at the **Chicago Section** (*R. L. Opila*) in November. Example was the new starch-gluten separation plant at Corn Products, where the wet starch process is now subject to control through careful instrumentation . . . Members of the **Fairfield County Chemical Engineering Society** heard Henry S. Byrne, Du Pont, discuss the development of Delrin polyacetal resin in October. W. R. Collings, head of Dow Corning, told the **Rocky Mountain Section** (*Robert E. Gustafson*) some of his early experiences at Dow. Collings, a director of A.I.Ch.E., also talked a bit about Institute affairs. . . . The importance of the local section in maintaing an atmosphere essential to professional growth was stressed by F. J. Van Antwerpen at the **Atlanta Section** (*R. L. Meek*) in October. . . . A tour through Imperial Sugar's refinery was one item on the agenda for **South Texas Section** (*W. G. Domask*) in November. . . . The polystyrene manufacturing operations at Koppers Kobuta were viewed by the **Pittsburgh Section** (*G. J. Haddad*) in November.

SITUATIONS WANTED

(continued from page 140)

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News and Notes of A.I.Ch.E.

A New Decade—A few stray thoughts as we begin the 1960's: This is the year that the economists have been talking about for so long; the economy of the United States and of the world will begin to rise to astronomical heights. After the Fabulous Fifties we're going to have the Sensational Sixties. These serve only to make us realize, however, that we are entering a great new era. For those members of A.I.Ch.E. who are supervising other engineers or are hiring new graduates in engineering, here is an idea borrowed from our president of last year, D. L. Katz: The young men you hire now will be retiring some time after the year 2000. As you think of the changes which are going to occur in the next forty years—new technologies and new challenges—what better advice can you give these young men than to become members of their professional and technical associations in order to help them to stay abreast of the rapidly flooding engineering tide?

San Francisco Meeting—The San Francisco Annual Meeting surpassed all expectations when almost 1,800 chemical engineers formed on the registration lines. The Local Section did an astounding job of hosting the meeting, and the membership owes them a debt of gratitude. Council met during the Saturday preceding the meeting and discussed many of the reports of committees that had projects or questions of policy to be decided. One of the important items of business was for Council to declare elected the winners of the 1959 campaign. Jerry McAfee is, of course, the president for 1960; the vice president elected by the members is J. J. Healy; and the four elected directors are D. A. Dahlstrom, C. R. Wilke, K. H. Hachmuth, and W. K. Menke. Reports before Council were made for the Nuclear Standards Board by S. I. Winde and for the Membership Committee by Irv Leibson; W. M. Carlson, Chairman of the Machine Computation Committee, showed Council the first A.I.Ch.E. Computer Manual, this one on Line Sizing, which is on sale for $30 a copy. Karl Hachmuth, newly elected Director and also Chairman of the Research Committee, discussed a new research program which the committee is preparing. Tom Walsh, newly elected Chairman of the Career Guidance Committee, reported for Ray Katzen, who could not attend the meeting, and Hugh Guthrie, Chairman of the Program Committee for 1959, who will be succeeded in 1960 by Norman Morash, reported on the activities of the Program Committee during the year. Council also thanked R. H. Wilhelm for the excellent Annual Report, which, as mentioned before in this column, has been sent to all members; there are, however, a few extra copies if anyone needs them. And again all the membership is reminded that anyone wanting a Directory of members, giving the names and addresses, need just drop a card to the Secretary's office.

During this meeting, too, Council Liaison Members were selected for the various committees and for Local

Sections. A brief explanation: Each member of Council is personally responsible for certain committees of A.I.Ch.E. and for certain Local Sections. He is supposed to familiarize himself with the problems of these groups and to act as a friend at court for them at Council meetings. It is the Council member who determines when a committee chairman will report at a Council meeting, depending upon the problems involved.

Other business included approval of the budget for the A.I.Ch.E. during 1960 and reports on the continuing Member-Giving Campaign, plus a large number of committee appointments, acceptance of invitations from Local Sections for national meetings, etc.

Special Lecture Series—At San Francisco ninety-seven chemical engineers registered for the lecture by Dr. G. E. P. Box and J. S. Hunter entitled "Process Development by Statistical Methods." As a matter of fact, the lecture was so popular that many had to be turned away, and both Dr. Box and Dr. Hunter have agreed to repeat the lecture at Atlanta. The Special Lecture Series Committee met during the Annual Meeting with R. H. Wilhelm, who will be the chairman for 1960. Right now the committee is considering what subjects will be discussed at the next Annual Meeting in Washington; so 1960 will see two of these lectures, the one repeated at Atlanta and the other given in Washington on a subject yet to be selected by the committee. Strangely enough, the new chairman, Professor Wilhelm, was the Council member who, acting as liaison with the Program Committee, presented the whole idea of the Special Lectures when it was approved back in 1958 at the Montreal meeting. For those of the membership who are not acquainted with this series, it consists of highly technical educational programs in specific fields of engineering. The lectures are reimbursed, special fees are charged, and the lecture lasts all day.

Science Award Survey—Ray Katzen's committee on Career Guidance made a rather interesting survey, this past year, of Local Sections. It tried to find out from the sections how many were involved in some sort of science award or science contest for high school or college students. The committee report included a chart showing that 30% of the Institute's Local Sections are cooperating in some way with high schools and colleges—giving them an award, sponsoring a contest, or doing something to forward chemical engineering or careers in engineering.

Rochester Movie—The Local Section in Rochester has cooperated with the Rochester Council of Scientific Societies in producing a twelve-minute movie and a 43-slide presentation on career guidance for use in high schools. Jim Oldshue, a well known member of A.I.Ch.E., was president of the Rochester Council, and Clark Morin helped vitally. Others involved in the guidance program in Rochester were Ed Garretson, Carl Gath, Al Ackoff, and Bob Donaldson. This news is gleaned from a very excellent report from the Rochester Section on 1958-59, and I think it would be a good idea if all Local Section chairmen were to write to C. R. Adler, Secretary of the Rochester Section, for a copy.

The Chicago Section is going to have a one-day symposium on Tuesday, February 23, 1960, at the Palmer House. It will cover engineering economics and computer-controlled process units.

F. J. V. A.

how to meter small quantities of liquid accurately

THERE'S no basic change in the physical properties of a liquid whether you pump large or small volumes. But as the volume being pumped approaches the milliliters per hour (ml/hr) range, several constant characteristics of liquids tend to become serious problems. Metering success depends on how well these problems are solved by pump design and operating practice.

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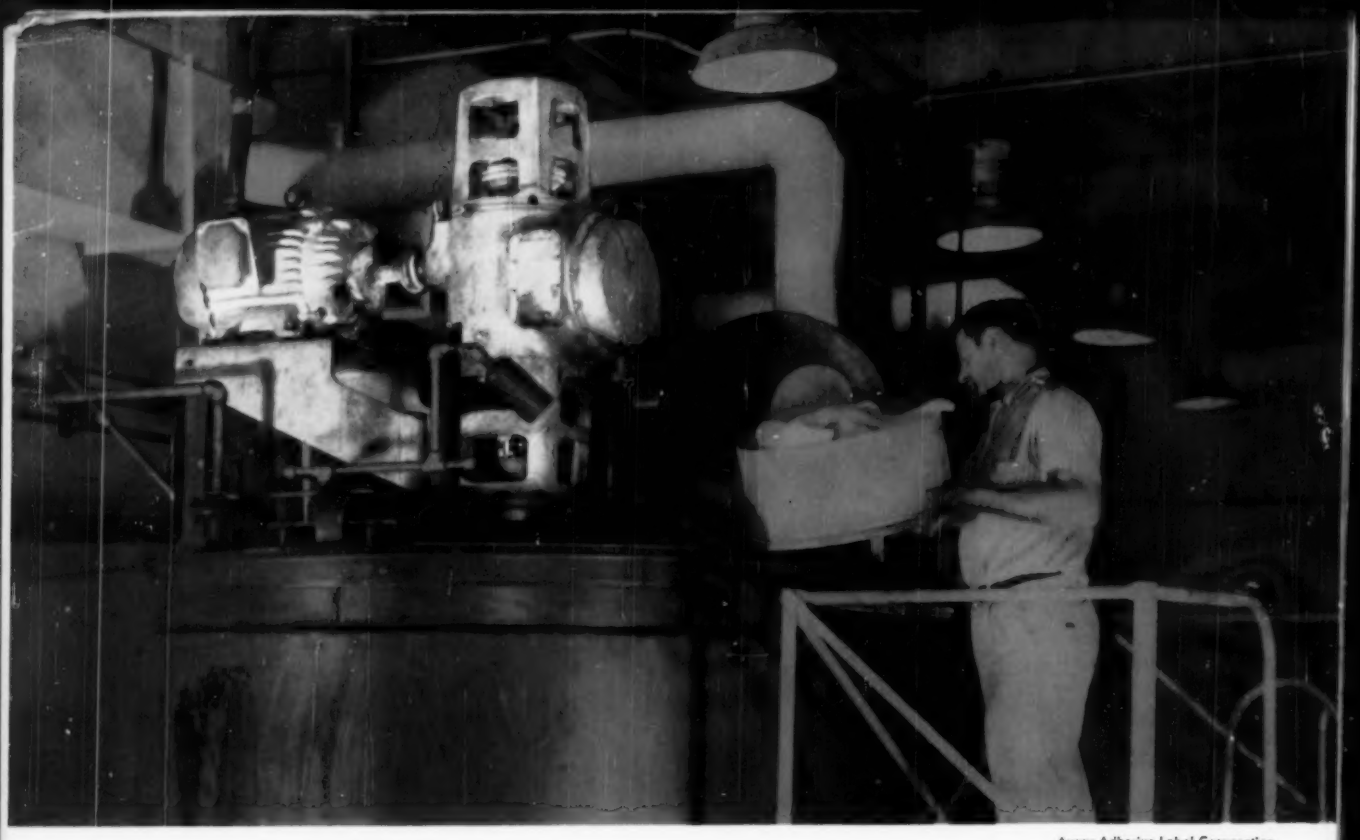

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